Switching Regulator IC for Buck Converter

Current Mode Control w/ 40V/1A MOSFET

■ GENERAL DESCRIPTION

The NJW4153 is a buck converter with 40V/1A MOSFET. It corresponds to high oscillating frequency, and Low ESR Output Capacitor (MLCC) within wide input range from 4.6V to 40V. Therefore, the NJW4153 can realize downsizing of applications with a few external parts so that adopts current mode control.

Also, it has a soft start function, an over current protection and a thermal shutdown circuit.

It is suitable for power supply circuit of Micro Processor, DSP and so on that need fast transient response.

■ FEATURES

- Current mode Control
- Maximum Rating Input Voltage 45V
- Wide Operating Voltage Range 4.6V to 40V
- Switching Current 1.4A min.
- PWM Control
- Built-in Compensation Circuit
- Correspond to Ceramic Capacitor (MLCC)
- Oscillating Frequency 1MHz typ. (A ver.)
- Soft Start Function 4ms typ.
- UVLO (Under Voltage Lockout)
- Over Current Protection (Hiccup type)
- Thermal Shutdown Protection
- Standby Function
- Package Outline NJW4153U2 : SOT-89-5
  NJW4153KV1 : ESON8-V1

■ PRODUCT CLASSIFICATION

<table>
<thead>
<tr>
<th>Part Number</th>
<th>Version</th>
<th>Oscillation Frequency</th>
<th>Package</th>
<th>Operating Temperature Range</th>
</tr>
</thead>
<tbody>
<tr>
<td>NJW4153U2-A</td>
<td>A</td>
<td>1MHz typ.</td>
<td>SOT-89-5</td>
<td>General Spec. -40°C to +85°C</td>
</tr>
<tr>
<td>NJW4153KV1-A</td>
<td>A</td>
<td>1MHz typ.</td>
<td>ESON8-V1</td>
<td>General Spec. -40°C to +85°C</td>
</tr>
</tbody>
</table>
NJW4153

**PIN CONFIGURATION**

- **NJW4153U2**
  - Pin Function:
    1. ON/OFF
    2. GND
    3. IN-
    4. SW
    5. V+

- **NJW4153KV1**
  - Pin Function:
    1. SW
    2. N.C.
    3. V+
    4. N.C.
    5. ON/OFF
    6. GND
    7. N.C.
    8. IN-

** BLOCK DIAGRAM**

- ON/OFF: High: ON Low: OFF (Standby)
- UV/LO
- Low Frequency Control
- Standby ON/OFF
- 450kΩ
- Vref 0.8V
- Soft Start
- ER AMP
- PWM
- Buffer
- TSD
- Osc
- SOR
- OCP
- CURRENT SENSE
- SLOPE COMP.
- IN-
- SW
- GND
- V+
### Absolute Maximum Ratings (Ta=25°C)

<table>
<thead>
<tr>
<th>PARAMETER</th>
<th>SYMBOL</th>
<th>MAXIMUM RATINGS</th>
<th>UNIT</th>
</tr>
</thead>
<tbody>
<tr>
<td>Supply Voltage</td>
<td>V⁺</td>
<td>+45</td>
<td>V</td>
</tr>
<tr>
<td>V⁻ - SW pin Voltage</td>
<td>Vᵥₛwę</td>
<td>+45</td>
<td>V</td>
</tr>
<tr>
<td>IN- pin Voltage</td>
<td>Vᵢᵣ⁻</td>
<td>-0.3 to +6</td>
<td>V</td>
</tr>
<tr>
<td>ON/OFF pin Voltage</td>
<td>Vₒᵣₒᵣ⁻</td>
<td>+45</td>
<td>V</td>
</tr>
<tr>
<td>Power Dissipation</td>
<td>Pᵩ</td>
<td>SOT-89-5</td>
<td>625 (*1) mW</td>
</tr>
<tr>
<td></td>
<td></td>
<td>ESON8-V1</td>
<td>600 (*3) mW</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>1,800 (*4) mW</td>
</tr>
<tr>
<td>Junction Temperature Range</td>
<td>Tⱼ</td>
<td>-40 to +150</td>
<td>°C</td>
</tr>
<tr>
<td>Operating Temperature Range</td>
<td>Tₒᵤᵣ</td>
<td>-40 to +85</td>
<td>°C</td>
</tr>
<tr>
<td>Storage Temperature Range</td>
<td>Tₛₒᵣ</td>
<td>-40 to +150</td>
<td>°C</td>
</tr>
</tbody>
</table>

(*1): Mounted on glass epoxy board. (76.2×114.3×1.6mm: based on EIA/JDEC standard size, 2Layers, Cu area 100mm²)

(*2): Mounted on glass epoxy board. (76.2×114.3×1.6mm: based on EIA/JDEC standard, 4Layers)

(For 4Layers: Applying 74.2×74.2mm inner Cu area and a thermal via hole to a board based on JEDEC standard JESD51-5)

(*3): Mounted on glass epoxy board. (101.5×114.5×1.6mm: based on EIA/JEDEC standard, 2Layers FR-4, with Exposed Pad)

(*4): Mounted on glass epoxy board. (101.5×114.5×1.6mm: based on EIA/JEDEC standard, 4Layers FR-4, with Exposed Pad)

(For 4Layers: Applying 99.5×99.5mm inner Cu area and a thermal via hole to a board based on JEDEC standard JESD51-5)

### Recommended Operating Conditions

<table>
<thead>
<tr>
<th>PARAMETER</th>
<th>SYMBOL</th>
<th>MIN.</th>
<th>TYP.</th>
<th>MAX.</th>
<th>UNIT</th>
</tr>
</thead>
<tbody>
<tr>
<td>Supply Voltage</td>
<td>V⁺</td>
<td>4.6</td>
<td>–</td>
<td>40</td>
<td>V</td>
</tr>
</tbody>
</table>

Ver.2013-03-21
# ELECTRICAL CHARACTERISTICS

(Unless otherwise noted, \(V^+=V_{ON/OFF}=12V, Ta=25^°C\))

<table>
<thead>
<tr>
<th>PARAMETER</th>
<th>SYMBOL</th>
<th>TEST CONDITION</th>
<th>MIN.</th>
<th>TYP.</th>
<th>MAX.</th>
<th>UNIT</th>
</tr>
</thead>
</table>

## Under Voltage Lockout Block

<p>| | | | | | | |</p>
<table>
<thead>
<tr>
<th></th>
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</thead>
<tbody>
<tr>
<td>ON Threshold Voltage</td>
<td>(V_{T_{ON}})</td>
<td>(V^+=L \rightarrow H)</td>
<td>4.3</td>
<td>4.45</td>
<td>4.6</td>
<td>V</td>
</tr>
<tr>
<td>OFF Threshold Voltage</td>
<td>(V_{T_{OFF}})</td>
<td>(V^+=H \rightarrow L)</td>
<td>4.2</td>
<td>4.35</td>
<td>4.5</td>
<td>V</td>
</tr>
<tr>
<td>Hysteresis Voltage</td>
<td>(V_{HYS})</td>
<td></td>
<td>70</td>
<td>100</td>
<td>–</td>
<td>mV</td>
</tr>
</tbody>
</table>

## Soft Start Block

<p>| | | | | | | |</p>
<table>
<thead>
<tr>
<th></th>
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</tr>
</thead>
<tbody>
<tr>
<td>Soft Start Time</td>
<td>(T_{SS})</td>
<td>(V_B=0.75V)</td>
<td>2</td>
<td>4</td>
<td>8</td>
<td>ms</td>
</tr>
</tbody>
</table>

## Oscillator Block

<p>| | | | | | | |</p>
<table>
<thead>
<tr>
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<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Oscillation Frequency</td>
<td>(f_{OSC})</td>
<td>A version, (V_{IN}=0.7V)</td>
<td>900</td>
<td>1,000</td>
<td>1,100</td>
<td>kHz</td>
</tr>
<tr>
<td>Oscillation Frequency (Low Frequency Control)</td>
<td>(f_{OSC_LOW})</td>
<td>(V_{IN}=0.4V)</td>
<td>–</td>
<td>370</td>
<td>–</td>
<td>kHz</td>
</tr>
<tr>
<td>Oscillation Frequency deviation (Supply voltage)</td>
<td>(f_{D^+})</td>
<td>(V^+=4.6) to 40V</td>
<td>–</td>
<td>1</td>
<td>–</td>
<td>%</td>
</tr>
<tr>
<td>Oscillation Frequency deviation (Temperature)</td>
<td>(f_{DT})</td>
<td>(Ta=-40^°C) to +85°C</td>
<td>–</td>
<td>5</td>
<td>–</td>
<td>%</td>
</tr>
</tbody>
</table>

## Error Amplifier Block

<p>| | | | | | | |</p>
<table>
<thead>
<tr>
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<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Reference Voltage</td>
<td>(V_B)</td>
<td></td>
<td>-1.0%</td>
<td>0.8</td>
<td>+1.0%</td>
<td>V</td>
</tr>
<tr>
<td>Input Bias Current</td>
<td>(I_B)</td>
<td></td>
<td>-0.1</td>
<td>–</td>
<td>+0.1</td>
<td>µA</td>
</tr>
</tbody>
</table>

## PWM Compare Block

<p>| | | | | | | |</p>
<table>
<thead>
<tr>
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</tr>
</thead>
<tbody>
<tr>
<td>Maximum Duty Cycle</td>
<td>(M_{AXDUTY})</td>
<td>(V_{IN}=0.7V)</td>
<td>85</td>
<td>90</td>
<td>–</td>
<td>%</td>
</tr>
<tr>
<td>Minimum ON time</td>
<td>(t_{GN_min})</td>
<td></td>
<td>–</td>
<td>140</td>
<td>180</td>
<td>ns</td>
</tr>
</tbody>
</table>

## Over Current Protection Block

<p>| | | | | | | |</p>
<table>
<thead>
<tr>
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<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Cool Down Time</td>
<td>(t_{COOL})</td>
<td></td>
<td>–</td>
<td>8</td>
<td>–</td>
<td>ms</td>
</tr>
</tbody>
</table>

## Output Block

<p>| | | | | | | |</p>
<table>
<thead>
<tr>
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<th></th>
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<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Output ON Resistance</td>
<td>(R_{ON})</td>
<td>(I_{SW}=1A)</td>
<td>–</td>
<td>0.45</td>
<td>0.75</td>
<td>Ω</td>
</tr>
<tr>
<td>Switching Current Limit</td>
<td>(I_{LIM})</td>
<td></td>
<td>1.4</td>
<td>1.9</td>
<td>2.4</td>
<td>A</td>
</tr>
<tr>
<td>SW Leak Current</td>
<td>(I_{LEAK})</td>
<td>(V_{ON/OFF}=0V, V^+=45V, V_{SW}=0V)</td>
<td>–</td>
<td>–</td>
<td>1</td>
<td>µA</td>
</tr>
</tbody>
</table>

## ON/OFF Block

<p>| | | | | | | |</p>
<table>
<thead>
<tr>
<th></th>
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<th></th>
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<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>ON Control Voltage</td>
<td>(V_{ON})</td>
<td>(V_{ON/OFF}=L \rightarrow H)</td>
<td>1.6</td>
<td>–</td>
<td>–</td>
<td>V</td>
</tr>
<tr>
<td>OFF Control Voltage</td>
<td>(V_{OFF})</td>
<td>(V_{ON/OFF}=H \rightarrow L)</td>
<td>0</td>
<td>–</td>
<td>0.5</td>
<td>V</td>
</tr>
<tr>
<td>Pull-down Resistance</td>
<td>(R_{PD})</td>
<td></td>
<td>–</td>
<td>450</td>
<td>–</td>
<td>kΩ</td>
</tr>
</tbody>
</table>

## General Characteristics

<p>| | | | | | | |</p>
<table>
<thead>
<tr>
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<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Quiescent Current</td>
<td>(I_{DD})</td>
<td>(R_L=) no load, (V_{IN}=0.7V)</td>
<td>–</td>
<td>3.9</td>
<td>4.4</td>
<td>mA</td>
</tr>
<tr>
<td>Standby Current</td>
<td>(I_{DD_STB})</td>
<td>(V_{ON/OFF}=0V)</td>
<td>–</td>
<td>–</td>
<td>1</td>
<td>µA</td>
</tr>
</tbody>
</table>
### TYPICAL APPLICATIONS

![Circuit Diagram](image)

- **V**
- **IN**
- **C**
- **OUT**
- **R**

**ON/OFF:**
- **High:** ON
- **Low:** OFF (Standby)
TYPICAL CHARACTERISTICS

Reference Voltage vs. Supply Voltage
(Ta=25°C)

Quiescent Current vs. Supply Voltage
(RL=no load, VIN-=0.7V, Ta=25°C)

Oscillation Frequency vs. Supply Voltage
(A ver., VIN-=0.7V, Ta=25°C)
TYPICAL CHARACTERISTICS

Reference Voltage vs. Temperature
(V+=12V)

Switching Current Limit vs. Temperature
(V+=4.6V)

Output ON Resistance vs. Temperature
(V+=4.6V, V+=12V, V+=40V)

Under Voltage Lockout Voltage vs. Temperature
(V+=12V, V=0.75V)

Soft Start Time vs. Temperature
(V+=12V, V=0.75V)

Oscillation Frequency vs Temperature
(A ver., V+=12V, V+=0.7V)

Reference Voltage vs. Temperature
(V+=12V)

Switching Current Limit vs. Temperature
(V+=4.6V)

Output ON Resistance vs. Temperature
(V+=4.6V, V+=12V, V+=40V)

Under Voltage Lockout Voltage vs. Temperature
(V+=12V, V+=0.75V)

Soft Start Time vs. Temperature
(V+=12V, V+=0.75V)

Oscillation Frequency vs Temperature
(A ver., V+=12V, V+=0.7V)

Reference Voltage vs. Temperature
(V+=12V)

Switching Current Limit vs. Temperature
(V+=4.6V)

Output ON Resistance vs. Temperature
(V+=4.6V, V+=12V, V+=40V)

Under Voltage Lockout Voltage vs. Temperature
(V+=12V, V+=0.75V)

Soft Start Time vs. Temperature
(V+=12V, V+=0.75V)
TYPICAL CHARACTERISTICS

Quiescent Current vs. Temperature
(RL=no load, VIN-=0.7V)

Standby Current vs. Temperature
(VON/OFF=0V)

Switching Leak Current vs. Temperature
(V+=45V, VON/OFF=0V, VSW=0V)

Minimum ON Time vs. Temperature
(V+=12V)

Maximum Duty Cycle vs. Temperature
(V+=12V, VIN-=0.7V)

Standby Current vs. Temperature
(VON/OFF=0V)
## PIN DESCRIPTIONS

<table>
<thead>
<tr>
<th>PIN NAME</th>
<th>PIN NUMBER</th>
<th>SOT-89-5</th>
<th>ESON8</th>
<th>FUNCTION</th>
</tr>
</thead>
</table>
| ON/OFF   | 1          | 5        |       | ON/OFF Control pin  
The ON/OFF pin internally pulls down with 450kΩ. Normal Operation at the time of High Level. Standby Mode at the time of Low Level or OPEN. |
| GND      | 2          | 6        |       | GND pin               |
| IN-      | 3          | 8        |       | Output Voltage Detecting pin  
Connects output voltage through the resistor divider tap to this pin in order to voltage of the IN- pin become 0.8V. |
| SW       | 4          | 1        |       | Switch Output pin of Power MOSFET |
| V+       | 5          | 3        |       | Power Supply pin for Power Line |
| N.C.     | –          | 2, 4, 7  |       | Non connection        |
| Exposed PAD | –        | –        |       | Connect to GND (Only ESOP8 PKG) |
Description of Block Features

1. Basic Functions / Features

- **Error Amplifier Section (ER·AMP)**
  
  0.8V±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 over 0.8V, inserts resistor divider.
  
  Because the optimized compensation circuit is built-in, the application circuit can be composed of minimum external parts.

- **PWM Comparator Section (PWM), Oscillation Circuit Section (OSC)**
  
  The NJW4153 uses a constant frequency, current mode step down architecture. The oscillation frequency is 1,000kHz (typ.) at A version. The PWM signal is output by feedback of output voltage and slope compensation switching current at the PWM comparator block.
  
  The maximum duty ratio is 90% (typ.).
  
  The minimum ON time is limited to 140nsec (typ.).

  The buck converter of ON time is decided the following formula.

  \[
  t_{on} = \frac{V_{OUT}}{V_{IN} \times f_{OSC}} \ [s]
  \]

  \(V_{IN}\) shows input voltage and \(V_{OUT}\) shows output voltage.
  
  When the ON time becomes below in \(t_{ON\_min}\), in order to maintain output voltage at a stable state, change of duty or pulse skip operation may be performed.

- **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 1.4A(min.) the overcurrent protection function. In case of step-down converter, the forward direction bias voltage is generated with inductance current that flows into the external regenerative diode when MOSFET is turned off.
  
  The SW pin allows voltage between the V+ pin and the SW pin up to +45V. However, you should use an Schottky diode that has low saturation voltage.

- **Power Supply, GND pin (V+ and GND)**
  
  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 GND 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 \( V^+ = 4.45V \) (typ.) and IC operation starts. When power supply voltage is low, IC does not operate because the UVLO circuit operates. There is 100mV (typ.) 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 0.75V. The soft start circuit operates after the release UVLO and/or recovery from thermal shutdown. The operating frequency is controlled with a low frequency 370kHz, until voltage or the IN- pin becomes approximately 0.65V.

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**Fig. 1. Startup Timing Chart**
Description of Block Features (Continued)

- Over Current Protection Circuit (OCP)

NJW4153 contains overcurrent protection circuit of hiccup architecture. The overcurrent protection circuit of hiccup architecture is able to decrease heat generation at the overload.

The NJW4153 output returns automatically along with release from the over current condition. At when the switching current becomes \( I_{\text{ILIM}} \) 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.

When IN- pin voltage becomes 0.5V or less, it operates with 370kHz (typ.). At the same time starts pulse counting, and stops the switching operation when the overcurrent detection continues approx 1ms.

After NJW4153 switching operation was stopped, it restarts by soft start function after the cool down time of approx 8ms (typ.).

![Timing Chart at Over Current Detection](image)

- Thermal Shutdown Function (TSD)

When Junction temperature of the NJW4153 exceeds the 165°C*, internal thermal shutdown circuit function stops SW function. When junction temperature decreases to 150°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

The NJW4153 stops the operating and becomes standby status when the ON/OFF pin becomes less than 0.5V. The ON/OFF pin internally pulls down with 450kΩ, therefore the NJW4153 becomes standby mode when the ON/OFF pin is OPEN. You should connect this pin to \( V^* \) when you do not use standby function.
Application Information

Inductors

Because a large current flows to the inductor, you should select the inductor with the large current capacity not to saturate. Optimized inductor value is determined by the input voltage and output voltage.

The Optimized inductor value: (It is a reference value.)

\[
\begin{align*}
V_{\text{IN}}=12\text{V} & \rightarrow V_{\text{OUT}}=5.0\text{V} \quad : L \leq 10\mu\text{H} \\
V_{\text{IN}}=24\text{V} & \rightarrow V_{\text{OUT}}=5.0\text{V} \quad : L \leq 10\mu\text{H}
\end{align*}
\]

You should set the inductor as a guide from above mentioned value to half value. Reducing L decreases the size of the inductor. However a peak current increases and adversely affects the efficiency. (Fig. 3.)

Moreover, you should be aware that the output current is limited because it becomes easy to operating to the overcurrent limit.

The peak current is decided the following formula.

\[
\Delta I_L = \frac{(V_{\text{IN}} - V_{\text{OUT}})}{L \times V_{\text{IN}} \times f_{\text{OSC}}} [\text{A}]
\]

\[
I_{pk} = I_{\text{OUT}} + \frac{\Delta I_L}{2} [\text{A}]
\]

Fig. 3. Inductor Current State Transition (Continuous Conduction Mode)
Application Information (Continued)

• 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.

• 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 the NJW4153 performance due to input voltage fluctuation. Therefore insert an input capacitor as close to the MOSFET as possible. A ceramic capacitor is the optimal for input capacitor.

The effective input current can be expressed by the following formula.

\[ I_{\text{RMS}} = I_{\text{OUT}} \times \sqrt{\frac{V_{\text{OUT}} \times (V_{\text{IN}} - V_{\text{OUT}})}{V_{\text{IN}}}} \text{[A]} \]

In the above formula, the maximum current is obtained when \( V_{\text{IN}} = 2 \times V_{\text{OUT}} \), and the result in this case is \( I_{\text{RMS}} = I_{\text{OUT} (\text{MAX})} / 2 \).

When selecting the input capacitor, carry out an evaluation based on the application, and use a capacitor that has adequate margin.

• Output Capacitor

An output capacitor stores power from the inductor, and stabilizes voltage provided to the output. Because NJW4153 corresponds to the output capacitor of low ESR, the ceramic capacitor is the optimal for compensation.

The Optimized capacitor value: (It is a reference value.)

\[ V_{\text{OUT}} = 5.0V \quad \Rightarrow \quad C_{\text{OUT}} >= 22 \mu \text{F} \]

In addition, you should consider varied characteristics of capacitor (a frequency characteristic, a temperature characteristic, a DC bias characteristic and so on) and unevenness peculiar to a capacitor supplier enough. Therefore when selecting a capacitors, you should confirm the characteristics with supplier datasheets.

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

The output ripple noise can be expressed by the following formula.

\[ V_{\text{ripple(p-p)}} = ESR \times \Delta I_L \text{[V]} \]

The effective ripple current that flows in a capacitor (\( I_{\text{rms}} \)) is obtained by the following equation.

\[ I_{\text{rms}} = \frac{\Delta I_L}{2\sqrt{3}} \text{[Arms]} \]
Setting Output Voltage, Compensation Capacitor

The output voltage $V_{OUT}$ is determined by the relative resistances of $R_1$, $R_2$. The current that flows in $R_1$, $R_2$ must be a value that can ignore the bias current that flows in ER AMP:

$$V_{OUT} = \left( \frac{R_2}{R_1} + 1 \right) \times V_b \ [V]$$

The zero points are formed with $R_2$ and $C_{FB}$, and it makes for the phase compensation of NJW4153. The zero point is shown the following formula.

$$f_{z1} = \frac{1}{2 \times \pi \times R_2 \times C_{FB}} \ [Hz]$$

You should set the zero point as a guide from 30kHz to 50kHz.
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.4. shows a current loop at step-down converter. Especially, should lay out high priority the loop of \( C_{\text{IN}}-\text{SW}-\text{SBD} \) that occurs rapid current change in the switching. It is effective in reducing noise spikes caused by parasitic inductance.

![Current Loop at Buck Converter](image)

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. 5. shows example of wiring at buck converter. Fig. 6 shows the PCB layout example.

![Board Layout at Buck Converter](image)

To avoid the influence of the voltage drop, the output voltage should be detected near the load.

Because \( \text{IN} \)-pin is high impedance, the voltage detection resistance: \( R_1/R_2 \) is put as much as possible near IC(\( \text{IN} \)).

Separate Digital(Signal) GND from Power GND

The condenser is connected near an IC.
Connect Signal GND line and Power GND line on backside pattern

Fig. 6. Layout Example (upper view)
Calculation of Package Power

A lot of the power consumption of buck converter occurs from the internal switching element (Power MOSFET).

Power consumption of NJW4153 is roughly estimated as follows.

\[
\begin{align*}
\text{Input Power:} & \quad P_{\text{IN}} = V_{\text{IN}} \times I_{\text{IN}} \quad [\text{W}] \\
\text{Output Power:} & \quad P_{\text{OUT}} = V_{\text{OUT}} \times I_{\text{OUT}} \quad [\text{W}] \\
\text{Diode Loss:} & \quad P_{\text{DIODE}} = V_F \times I_{(av)} \times \text{OFF duty} \quad [\text{W}] \\
\text{NJW4153 Power Consumption:} & \quad P_{\text{LOSS}} = P_{\text{IN}} - P_{\text{OUT}} - P_{\text{DIODE}} \quad [\text{W}]
\end{align*}
\]

Where:

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

Efficiency (\(\eta\)) is calculated as follows.

\[
\eta = \left(\frac{P_{\text{OUT}}}{P_{\text{IN}}}\right) \times 100 \quad [%]
\]

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).

---

(*5): Mounted on glass epoxy board. (76.2×114.3×1.6mm:based on EIA/JDEC standard size, 2Layers, Cu area 100mm²)

(*6): Mounted on glass epoxy board. (76.2×114.3×1.6mm:based on EIA/JDEC standard, 4Layers)

(For 4Layers: Applying 74.2×74.2mm inner Cu area and a thermal via hall to a board based on JEDEC standard JESD51-5)

(*7): Mounted on glass epoxy board. (101.5×114.5×1.6mm: based on EIA/JEDEC standard, 2Layers FR-4, with Exposed Pad)

(*8): Mounted on glass epoxy board. (101.5×114.5×1.6mm: based on EIA/JEDEC standard, 4Layers FR-4, with Exposed Pad)

(For 4Layers: Applying 99.5×99.5mm inner Cu area and a thermal via hole to a board based on JEDEC standard JESD51-5)

Fig. 7. Power Dissipation vs. Ambient Temperature Characteristics
Application Design Examples

Busk Converter Application Circuit

- IC: NJW4153U2-A
- Input Voltage: $V_{IN}=12V, 24V$
- Output Voltage: $V_{OUT}=5V$
- Output Current: $I_{OUT}=1A$
- Oscillation frequency: $f_{osc}=1MHz$

![Application Circuit Diagram](image)

Reference Qty. Part Number Description Manufacturer

<table>
<thead>
<tr>
<th>Reference</th>
<th>Qty.</th>
<th>Part Number</th>
<th>Description</th>
<th>Manufacturer</th>
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</thead>
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<td>NJW4153U2-A</td>
<td>Internal 1A MOSFET SW.REG. IC</td>
<td>New JRC</td>
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<td>L</td>
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<td>CDRH8D28HPNP-100N</td>
<td>Inductor 10μH, 3.4A(Ta=25°C) / 2.5A(Ta=100°C)</td>
<td>Sumida</td>
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<tr>
<td>SBD</td>
<td>1</td>
<td>CMS16</td>
<td>Schottky Diode 40V, 3A</td>
<td>Toshiba</td>
</tr>
<tr>
<td>C_{IN}</td>
<td>1</td>
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<td>Ceramic Capacitor 3225 10μF, 50V, X5R</td>
<td>Taiyo Yuden</td>
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<tr>
<td>C_{OUT}</td>
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<td>Ceramic Capacitor 3225 22μF, 25V, B</td>
<td>Murata</td>
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<tr>
<td>C_{FB}</td>
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<td>Std.</td>
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<td>30kΩ</td>
<td>Resistor 1608 30kΩ, ±1%, 0.1W</td>
<td>Std.</td>
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<tr>
<td>R2</td>
<td>1</td>
<td>160kΩ</td>
<td>Resistor 1608 160kΩ, ±1%, 0.1W</td>
<td>Std.</td>
</tr>
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</table>
Application Characteristics: NJW4153U2-A

- At V_{OUT}=5.0V setting (R1=30kΩ, R2=160kΩ)

Efficiency vs. Output Current
(A ver., V_{OUT}=5V, Ta=25°C)

- At V_{OUT}=3.3V setting (R1=47kΩ, R2=150kΩ)

Efficiency vs. Output Current
(A ver., V_{OUT}=3.3V, Ta=25°C)
# NJW4153

## Technical Information

### Inverting Converter Application Circuit

```
V+ SW
NJW4153 ON/OFF
L 10µH/3.4A
C+ 0.47µF/50V
L10µH/3.4A
COUT 22µF/25V
SBD
ON/OFF
High ON
Low OFF
(Standby)

Vin=15V
CIN 10µF/50V

COUT 22µF/25V

VOUT = -15V

R1 910kΩ

R2 51kΩ

f=1MHz
L=10µH
```

**Technical Information**

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<td>1</td>
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<td>Ceramic Capacitor 3225 10µF, 50V, X5R</td>
<td>Taiyo Yuden</td>
</tr>
<tr>
<td>COUT</td>
<td>1</td>
<td>GRM32EB31E226KE15</td>
<td>Ceramic Capacitor 3225 22µF, 25V, B</td>
<td>Murata</td>
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<tr>
<td>CC</td>
<td>1</td>
<td>GRM21BB31H474KA87</td>
<td>Ceramic Capacitor 2012 0.47µF, 50V, B</td>
<td>Murata</td>
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<td>CFB</td>
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<td>——</td>
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<td>Resistor 1608 910kΩ, ±1%, 0.1W</td>
<td>Std.</td>
</tr>
<tr>
<td>R2</td>
<td>1</td>
<td>51kΩ</td>
<td>Resistor 1608 51kΩ, ±1%, 0.1W</td>
<td>Std.</td>
</tr>
</tbody>
</table>

### Efficiency vs. Output Current

Efficiency vs. Output Current

\( f=1 \text{MHz} \)
\( L=10 \mu\text{H} \)

### Output Voltage vs. Output Current

Output Voltage vs. Output Current

\( f=1 \text{MHz} \)
\( L=10 \mu\text{H} \)
[CAUTION] The specifications on this databook are only given for information, without any guarantee as regards either mistakes or omissions. The application circuits in this databook are described only to show representative usages of the product and not intended for the guarantee or permission of any right including the industrial rights.