Design Example Using the NR263S

V_{OUT} = 5 V, $I_{OUT(MAX)}$ = 1 A

DC/DC Converter

Contents

1. Introduction

This document describes the design example of a power supply using the NR263S intended for the DC/DC converter that supports a 5 V/1 A (max.) output. The NR263S is a buck converter IC with a built-in power MOSFET. By using the peak current control method, the IC stably operates with a low ESR capacitor such as a ceramic capacitor.

The IC has the protections including overcurrent protection (OCP), undervoltage lockout (UVLO), and thermal shutdown (TSD).

This document contains the following: the specifications of the design example, circuit diagrams, the bill of materials, the setting examples of component constants, a pattern layout example, and the evaluation results of the power supply characteristics. For more details on the parts listed in this document, refer to the corresponding data sheets.

2. Power Supply Features

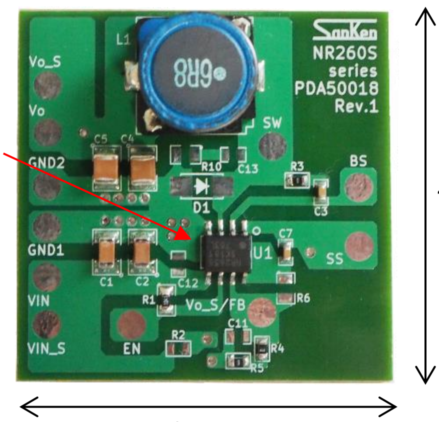
- Efficiency: 93% (V_{IN} = 9 V, V_O = 5 V, I_O = 0.5 A)
- Operation Modes:
  Normal Operation: Current Mode PWM Control
  Light Load Operation: Pulse Skipping Operation
- Few Components and Small Mounting Area
  Built-in power MOSFET
  Ceramic Capacitor can be used for Output Capacitor
  Built-in Phase Compensation Circuit
- Soft Start Function
  Soft-start Period Adjustment by External Capacitor
- Enable Function
- Protections
  Overcurrent Protections (OCP): Drooping Type, Auto-restart
  Thermal Shutdown (TSD): Auto-restart
  Undervoltage Lockedout (UVLO)
  Output Short Circuit Protection: Burst Oscillation Operation (Hiccup)

3. Application

- Audio Visual Equipment
- White Goods
- Auxiliary Power Supply
- Other Switched Mode Power Supplies (SMPS)

4. Design Example: Appearance

NR263S



40 mm

40 mm

5. Design Example

5.1 Power Supply Specifications

Parameter	Symbol	Conditions	Min.	Typ.	Max.	Unit
Input						
Input Voltage	V_{IN}		8	—	31	V
Output						
Rated Voltage	V_{OUT}		—	5	—	V
Rated Current[(1)]	I_{OUT}		—	—	1	A
Output Ripple Voltage	V_{RIPPLE}	V_{OUT} = 5 V, I_{OUT} = 1 A, C4 = 22 µF, C5 = 22 µF[(2)]	—	20	—	mV_{P-P}
Efficiency	η	V_{IN} = 9 V, I_{OUT} = 0.5 A, T_A = 25 °C	—	93	—	%
Environment						
Conduction Noise	—	T_A = 25 °C	As per CISPR22B / EN55022B			—
Temperature						
Operating Ambient Temperature[(1)]	T_{OP}		−40	—	85	°C

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(1) Must be used in the range of thermal derating. For details, refer to the NR263S data sheet.
(2) Low ESR ceramic capacitors can be used for C4 and C5.

5.2 Circuit Diagram

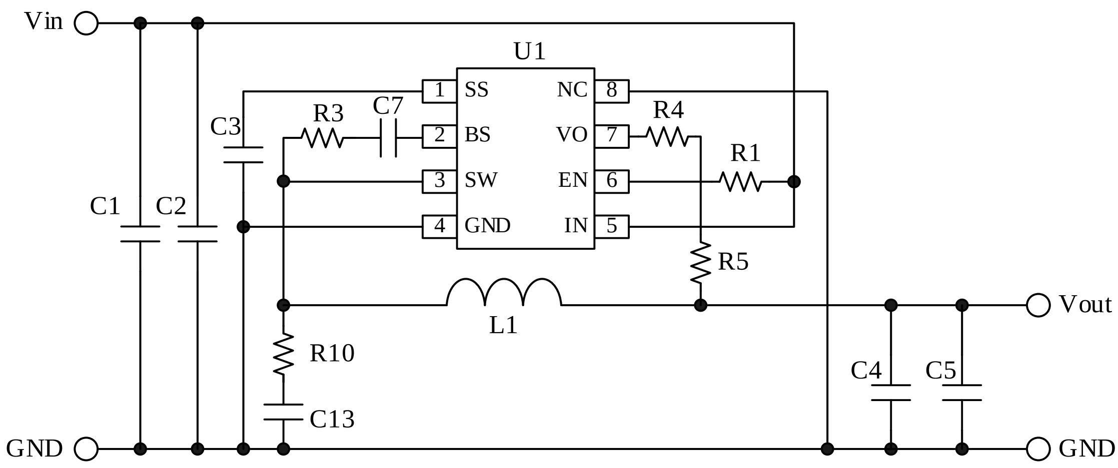


Figure 5-1. Circuit Diagram

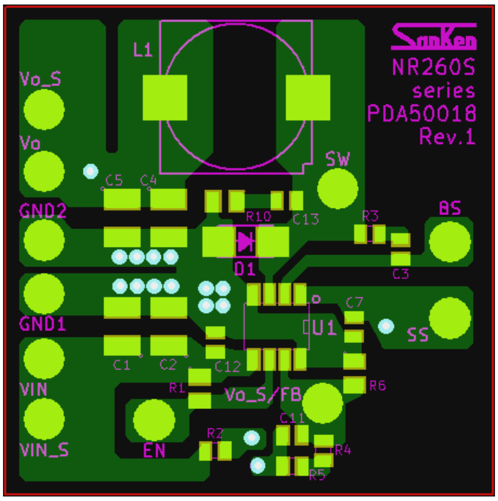
5.3 Bill of Materials

Part Symbol	Part Type	Ratings	Remarks
C1	Chip ceramic capacitor	10 µF, 50 V, 3216	
C2	Chip ceramic capacitor	10 µF, 50 V, 3216	
C3	Chip ceramic capacitor	0.1 µF, 50 V, 1608	
C4	Chip ceramic capacitor	22 µF, 25 V, 3225	Low ESR type
C5	Chip ceramic capacitor	22 µF, 25 V, 3225	Low ESR type
C7	Chip ceramic capacitor	0.047 µF, 50 V, 1608	
C13	Chip ceramic capacitor	Open	Adjustment capacitor
L1	Inductor	6.8 µH	SLF12575T-6R8N5R9-PF (TDK)
R1	Chip resistor	100 kΩ, 0.1 W, 1608	
R3	Chip resistor	0 Ω, 1608	Adjustment capacitor
R4	Chip resistor	0 Ω, 1608	Jumper
R5	Chip resistor	0 Ω, 1608	Jumper
R10	Chip resistor	Open	Adjustment capacitor
U1	Buck Converter IC	SOP8	NR263S (Sanken)

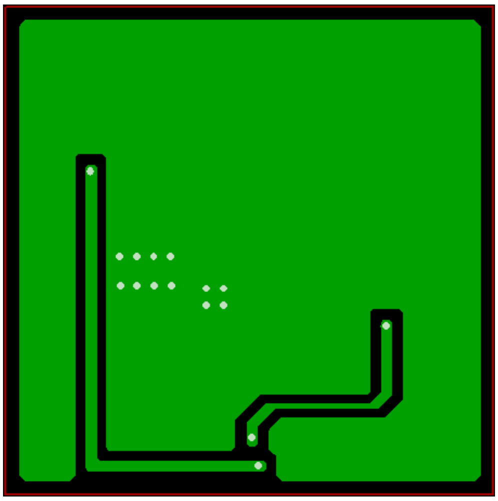
5.4 Pattern Layout Example

PCB dimensions: 40 mm × 40 mm.

Note that the pattern layout example only uses the parts illustrated in the circuit diagram below because this board is used for some other products.



(a) Top View



(b) Bottom View

Figure 5-2 Pattern Layout Example

6. Performance Data

All the performance data contained in this document were measured at a room temperature. Unless specifically noted, V_{IN} = 12 V, V_{OUT} = 5 V.

6.1 Start/Stop Operation

The NR263S has the undervoltage lockout. Figure 6-1 shows the startup characteristics of output voltage vs. input voltage (i.e., the IN pin voltage). When V_{OUT} = 5 V, the input voltage must be set to ≥8 V.

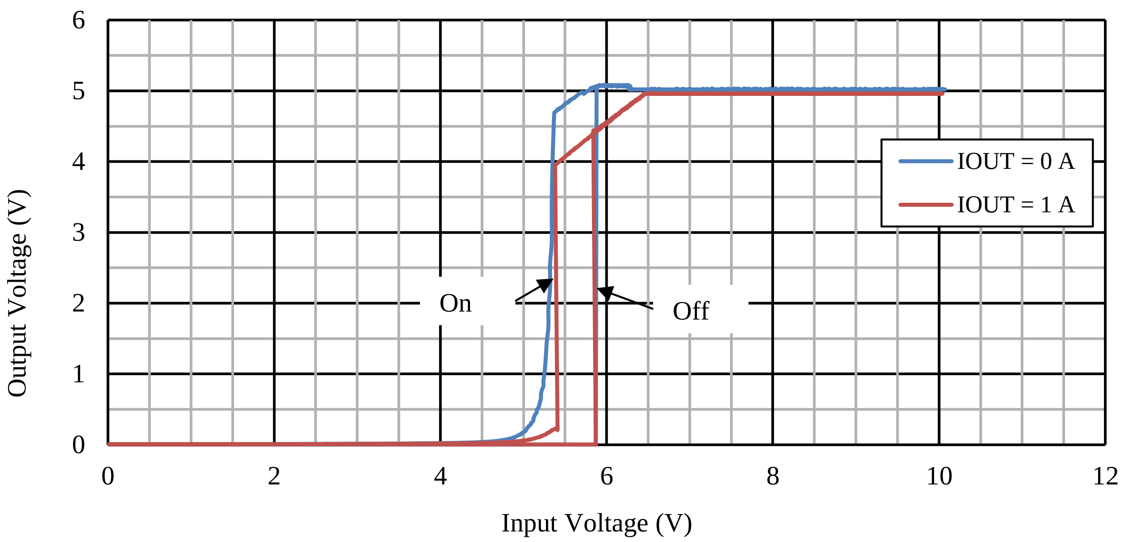


Figure 6-1. Output Voltage vs. Input Voltage

6.2 Overcurrent Protection

The NR263S has the drooping overcurrent characteristic. Figure 6-2 shows the overcurrent characteristics according to the input voltage.

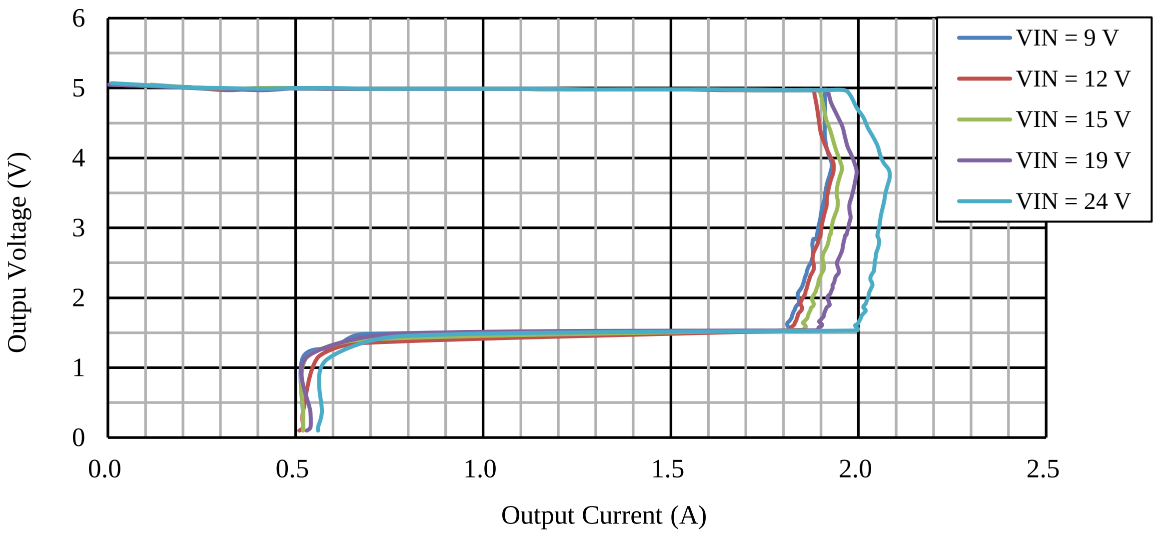


Figure 6-2. Overcurrent Protection Characteristics

6.3 Circuit Current at No Load

Figure 6-3 and Figure 6-4 show the IN pin input voltage dependance at no load (V_{OUT} = 5 V, I_{OUT} = 0 A) in operation and non-opetation, respectively.

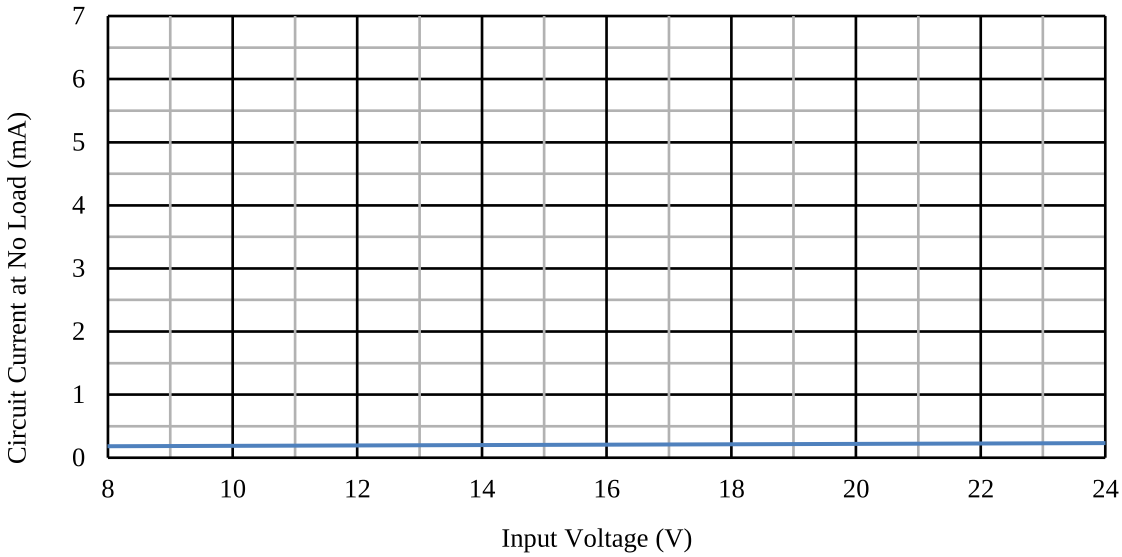


Figure 6-3. Circuit Current at No Load vs. Input Voltage in Operation

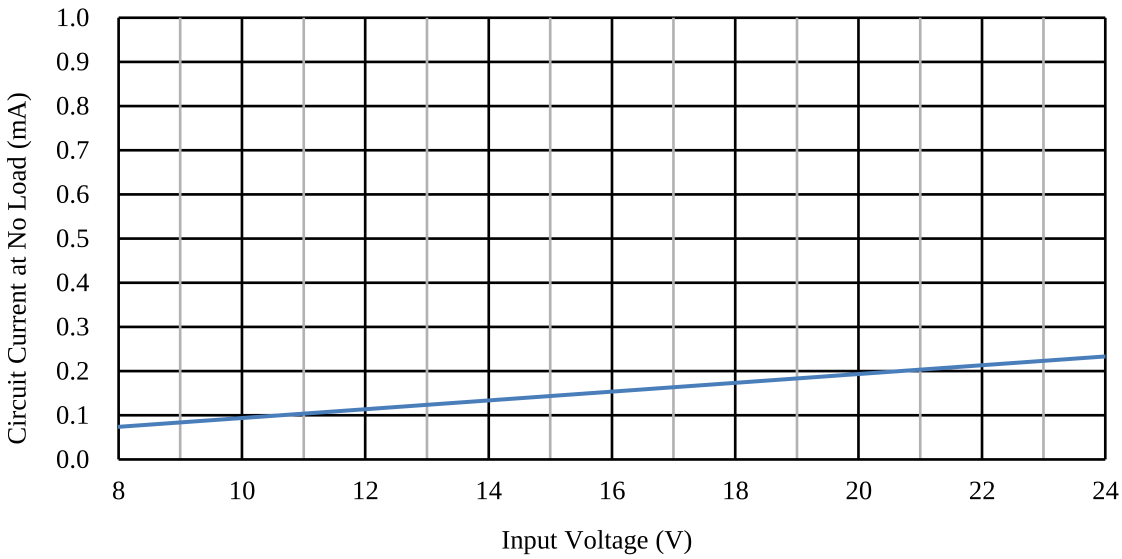


Figure 6-4. Circuit Current at No Load vs. Input Voltage in Non-opetation

6.4 Efficiency

Figure 6-5 shows the characteristics of power supply efficiency vs. output current.

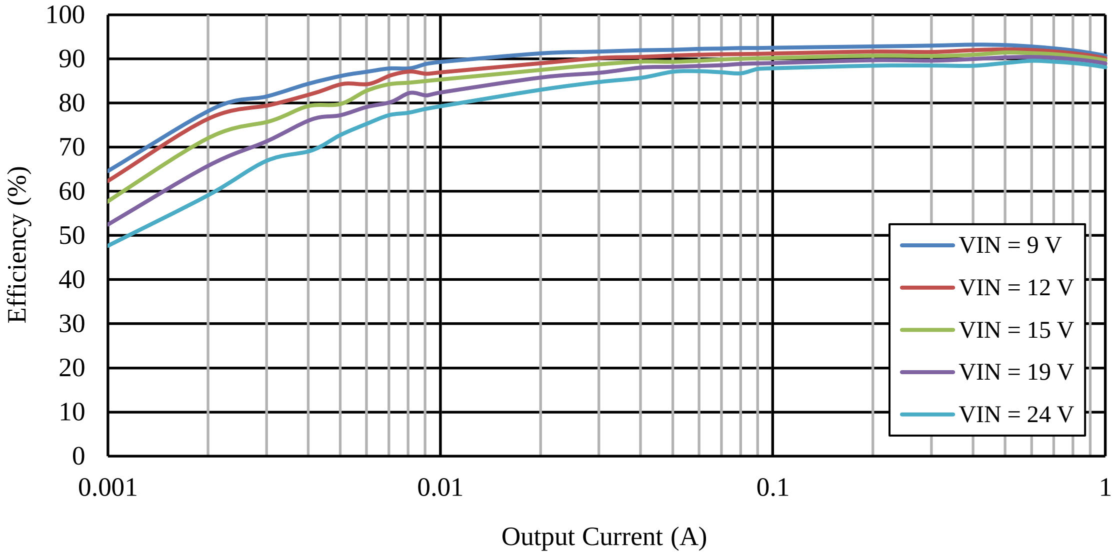


Figure 6-5. Efficiency vs. Output Current

6.5 Load Regulation

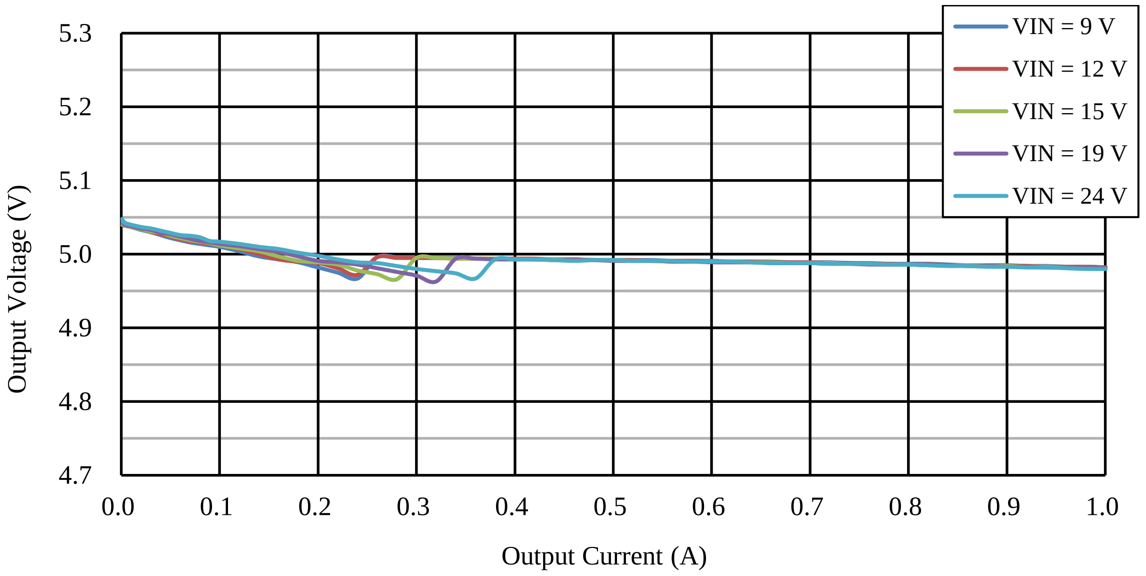


Figure 6-6. Output Voltage vs. Output Current

7. Operation Check

All the performance data contained in this document were measured at a room temperature. Unless specifically noted, V_{IN} = 12 V, V_{OUT} = 5 V.

For more details on the NR263S such as electrical characteristics and operational descriptions, refer to the data sheet.

7.1 Startup Operation

The soft start function is activated at power-on. The soft start period depends on the capacitance of the capacitor connected to the SS pin. Even when the IC starts with the enable function, the soft start function is activated.

Figure 7-1 and Figure 7-2 show the startup waveforms with the UVLO (the EN pin is pulled up to the IN pin) and enable function (external signal is input to the EN pin), respectively.

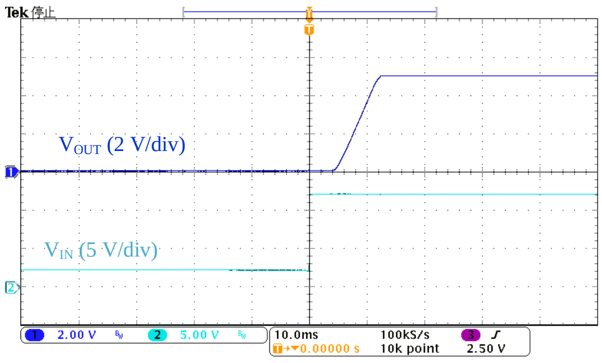


Figure 7-1. Operational Waveforms at Startup by UVLO (I_{OUT} = 250 mA, C_{SS} = 0.047 µF)

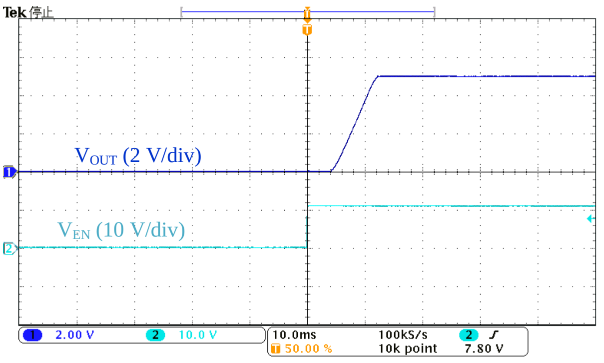


Figure 7-2. Operational Waveforms at Startup by Enable Function (I_{OUT} = 250 mA, C_{SS} = 0.047 µF)

7.2 Switching Operation

Figure 7-7 to Figure 7-3 show the operational waveforms according to the load.
The NR263S regulates the output voltage with the current mode PWM control. In a heavy load condition, the IC operates in the continuous conduction mode of PWM frequency of 500 kHz (typ.). In a light load condition, the IC enters the pulse skipping mode that reduces the oscillation frequency to improve efficiency. The minimum on-time is limited to 200 ns (typ.).

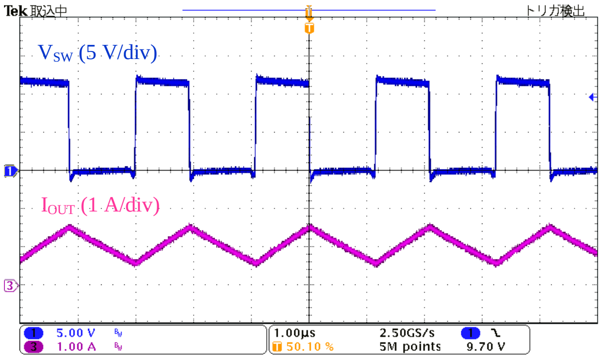


Figure 7-3. Operational Waveforms in Normal Operation (I_{OUT} = 1 A)

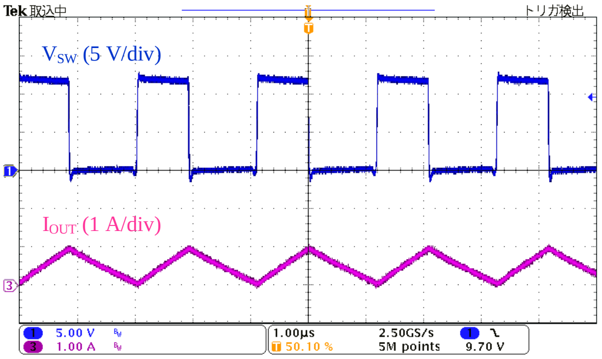


Figure 7-4. Operational Waveforms in Normal Operation (I_{OUT} = 0.45 A)

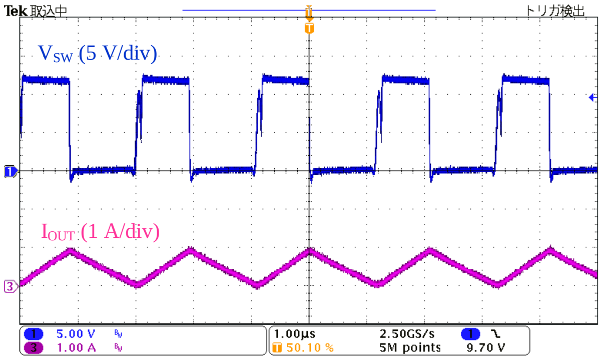


Figure 7-5. Operational Waveforms in Normal Operation (I_{OUT} = 0.42 A)

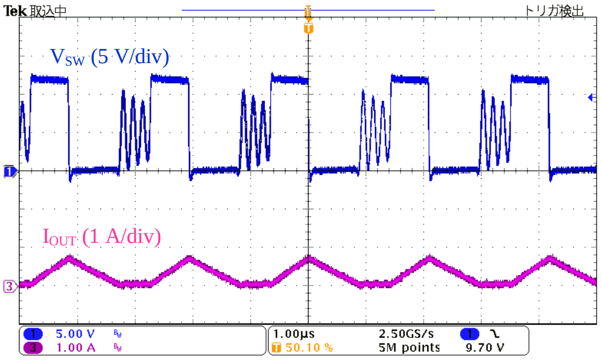


Figure 7-6. Operational Waveforms in Normal Operation (I_{OUT} = 0.25 A)

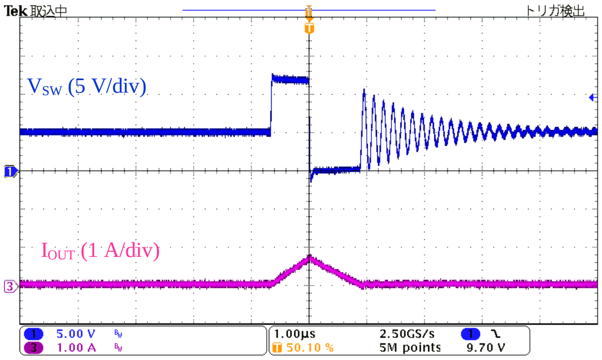


Figure 7-7. Operational Waveforms in Normal Operation (I_{OUT} = 10 mA)

7.3 Output Ripple Voltage

The design example has an output ripple voltage of about 20 mV_{P-P}. The bandwidth of the oscilloscope is set to 20 MHz.

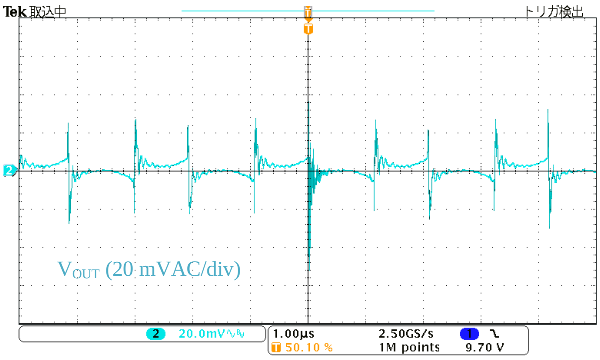


Figure 7-8. Output Ripple Voltage Waveform (I_{OUT} = 1 A)

7.4 Load Transient Reponse

Figure 7-9 to Figure 7-11 show the load transient response waveforms of output voltage when the change rate of the load current is 0.75 A/ms, 7.5 A/ms, and 75 A/ms, respectively.

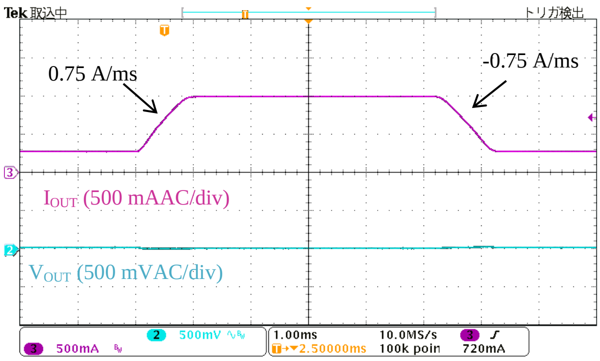


Figure 7-9. Load Transient Response Waveforms (0.75 A/ms)

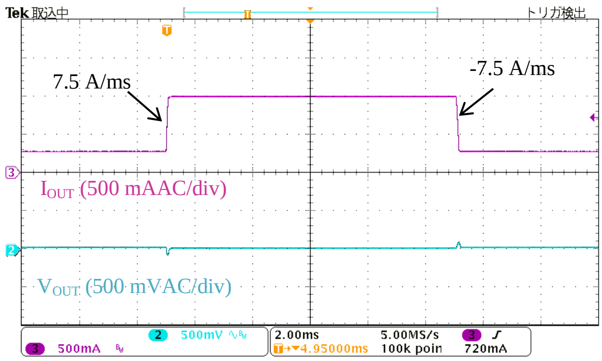


Figure 7-10. Load Transient Response Waveforms (7.5 A/ms)

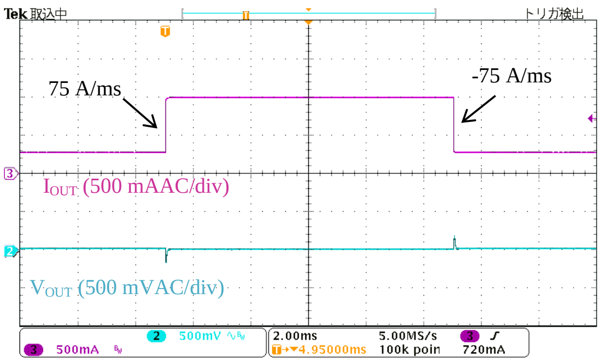


Figure 7-11. Load Transient Response Waveforms (75 ms/A)

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