Step-down DC/DC with LDOs

RN5T562

Development Specifications

Rev.1.5

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1. Outline

RN5T562 integrates CMOS-based step-down DC/DC converter and two low dropout regulators (LDOs) with low supply current. A low ripple, high efficiency step-down DC/DC converter can be easily composed of this IC with some external components such as inductor, capacitors and resistor. The self-oscillation frequency is up to 2MHz and it allows DCDC to use small inductor and capacitor.

Output enable/disable of regulators is individually controllable through external pins. In addition, this IC has the under voltage lockout function (UVLO), which powers off all the regulators with 2.20V (Typ.) UVLO threshold.

Also, RN5T562 has Thermal shutdown circuit which turns off all the regulators in the overheated state.

2. Feature

- Range of Input Voltage ..... 3.1V ~ 4.5V (DC/DC), 1.746V(1.8V-3.0%) ~ 4.5V (LDOs)
- Built-in Soft-start Function for DCDC
- Maximum Output Current..... 500mA (DC/DC), 200mA (LDOs)
- Accuracy Output Voltage ..... ±3.0% (LDOs Output)
- Output Voltage (LDO1) ..... Settable in 0.05V step in range of 1.2V to 3.3V
- Output Voltage (LDO2) ..... Settable in 0.05V step in range of 1.2V to 3.3V
- Output Voltage (DC/DC) ..... Setting external resistance ratio in the range of 0.9V to 2.0V
- Thermal Shutdown Circuit
- UVLO
- Package ..... QFN 16pins, 3mm × 3mm, t=0.8mm
- Process ..... CMOS

3. Application

- Power source for DMB.
- Power source for battery-powered equipment.

4. Ordering Information

RN5T562-XXXYYY

XXX : LDO1 Output Voltage.

YYY : LDO2 Output Voltage.

For example.

RN5T562-150180 : LDO1=1.50V, LDO2=1.80V.

5. Block Diagram

The block diagram of the device is shown below.

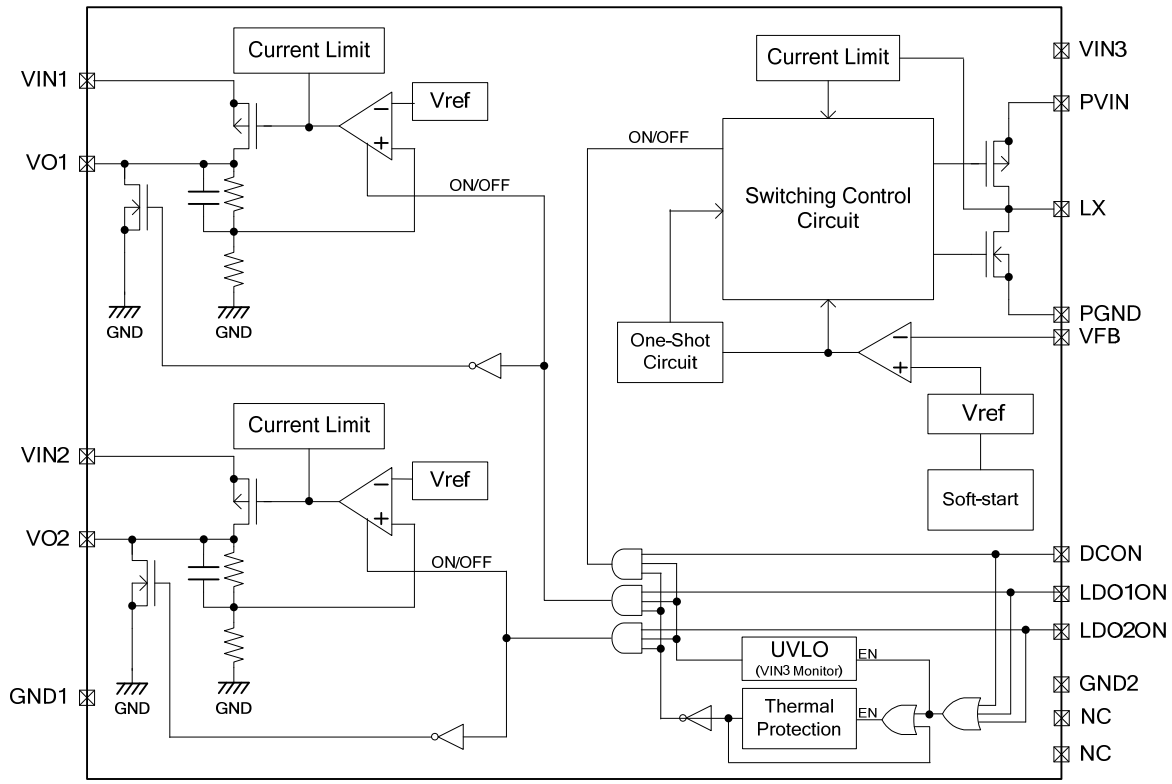


Fig 5-1 Block Diagram

6. Pin Configuration

QFN 16pins, 3mm × 3mm, t=0.8mm

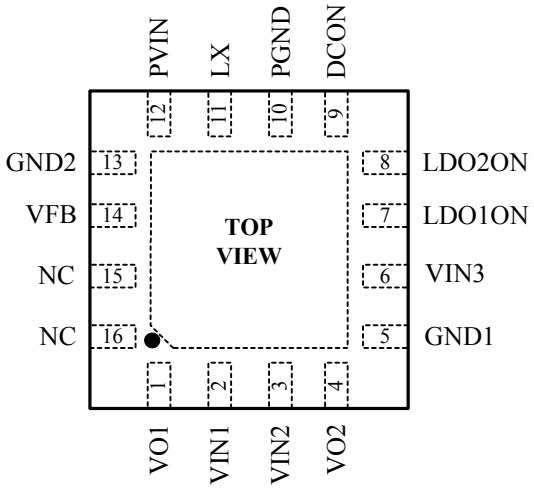


Fig 6-1 Pin Configuration

7. Pin Description

No.	Name	I/O	Function	Notes
1	VO1	O	Output voltage of LDO1.	
2	VIN1	PWR	Power supply for LDO1.	
3	VIN2	PWR	Power supply for LDO2.	
4	VO2	O	Output voltage of LDO2.	
5	GND1	GND	GND for LDO block, UVLO, and TSHUT.	
6	VIN3	PWR	Power supply for DC/DC converter control block, UVLO, and TSHUT.	
7	LDO1ON	I	Input of LDO1 for ON/OFF.	
8	LDO2ON	I	Input of LDO2 for ON/OFF.	
9	DCON	I	DC/DC ON/OFF control.	
10	PGND	GND	GND for DC/DC converter.	
11	LX	O	DC/DC converter switch output.	
12	PVIN	PWR	Power supply for DC/DC converter driver.	
13	GND2	GND	GND for DC/DC converter control block.	
14	VFB	I	Output voltage feedback input of DCDC converter.	
15	NC	-	Non-connect. Connect to GND.	
16	NC	-	Non-connect. Connect to GND.	

Table 7-1 Pin Description

8. Electrical Characteristics

8.1 Absolute Maximum Ratings

The operation exceeding "Absolute Maximum Ratings" below may cause permanent damage to the device.

The operation of the device within the stated ratings below is not guaranteed.

Symbol	Parameter	Condition	Rated Value	Units
V_{IN}	Power Input Pin Voltage	VIN1~3, PVIN pin	-0.3~6.0	V
V_{LX}	LX Pin Voltage	LX pin	-0.3~4.5	V
V_1 / V_2	VO1, VO2 Pin Voltage	VO1, VO2 pin	-0.3~4.5	V
V_{PIN}	Input Voltage Range	DCON, LDO1ON, LDO2ON	-0.3~VIN3+0.3	V
PD	Package Allowable Dissipation	Mounted on Board, T_a =70℃	950 *1	mW
T_{stg}	Storage Temperature	-	-55~+125	℃

Note*1: Derate 17.27 [mW/℃] above +70℃.

Table 8-1 Absolute Maximum Ratings

8.2 Recommended Operating Conditions

Symbol	Parameter	Condition	Min	Typ	Max	Units
-	Power Supply Voltage1	VIN1 pin VOUT1+0.3V＜1.746V	1.746 (1.8-3%)		4.5	V
		VIN1 pin VOUT1+0.3V≧1.746	VOUT1 +0.3		4.5	V
-	Power Supply Voltage2	VIN2 pin VOUT2+0.3V＜1.746V	1.746 (1.8-3%)		4.5	V
		VIN2 pin VOUT2+0.3V≧1.746	VOUT2 +0.3		4.5	V
-	Power Supply Voltage3	VIN3 pin	3.1		4.5	V
-	DC/DC Power Supply Voltage	PVIN pin	3.1		4.5	V
T_a	Temperature of Operation	-	-40		+85	℃

Table 8-2 Recommendation of Operation Conditions

8.3 Step-down DC/DC Converter Electrical Characteristics

Operating Conditions (unless otherwise specified) VIN1, VIN2, VIN3, PVIN = 3.6V, T_a = 25℃ L1=2.2μH, C_{OUT}=4.7μF

Symbol	Parameter	Condition	Min	Typ	Max	Units
-	Input Voltage Range	VIN3, PVIN pin	3.1		4.5	V
DVOUT	Output Voltage Range	-	0.9		2.0	V
DIOUT	Output current	VIN3=PVIN=3.1~4.5V			500	mA
DISS	Consumption Current	VIN3=PVIN=VFB=3.6V DIOUT=0mA, no switching		70		μA
DIOFF	Standby Current	VIN3=PVIN=4.5V OFF state			1	μA
DILIM	Limit detection Current	-	800			mA
VFB	FB Voltage	-	-1.5%	0.608	+1.5%	V
$\frac{\Delta VFB}{\Delta VIN}$	FB Line Regulation	VIN3=PVIN=3.1~4.5V DIOUT=DIOUTmax / 2		7		mV
$\frac{\Delta VFB}{\Delta T}$	FB Voltage Temperature Coefficient	-40℃≦Ta≦+85℃		±100		ppm/℃
t_r *2	Soft-start Time	-		120		μs
T_{ONmin}	Minimum-On-Time	-		120		ns

Table 8-3 Step-down DC/DC Converter Electrical Characteristics

Note*: Load Regulation, which is determined by DC resistance (DCR) on inductor, is given by:
Load Regulation (Typ) = DCR (Ω) × DIOUT (A).

Note*1: When all regulators are off, Soft-start time will be added up with UVLO output delay time for releasing.
t_r(Typ)= 120μs + 10μs(UVLO output delay time for releasing).

8.4 LDO1 Electrical Characteristics

Operating Conditions (unless otherwise specified) VIN1, VIN2, VIN3, PVIN = 3.6V, C_{OUT1} = 2.2μF, T_a = 25℃

Symbol	Parameter	Condition		Min	Typ	Max	Units
-	Input Voltage Range	VIN1 pin		1.746 (1.8-3%)		4.5	V
VOUT1*1	Output Voltage Range	-		1.2		3.3	V
IOUT1	Output Current	-				200	mA
VACC1	Output Voltage Accuracy	VOUT1+0.3V ≧1.746	VIN1=VOUT1+0.3V & IOUT1=IOUT1max, & VIN1=4.5V & IOUT1=50μA	-3		+3	%
		VOUT1+0.3V ＜1.746V	VIN1=1.746V & IOUT1=IOUT1max, & VIN1=4.5V & IOUT1=50μA				
ISHT1	Short Current	VO1=0V			120		mA
$\frac{\Delta VOUT1}{\Delta VIN}$	Line Regulation	VOUT1+0.3V ≧1.746	VOUT1+0.3V≦VIN1 ≦4.5V, IOUT1=IOUT1max /2			10	mV
		VOUT1+0.3V ＜1.746V	1.746V≦VIN1≦4.5V, IOUT1=IOUT1max /2				
$\frac{\Delta VOUT1}{\Delta IOUT1}$	Load Regulation	VIN1=3.6V 50μA＜IOUT1＜IOUT1max				30	mV
$\frac{\Delta VOUT1}{\Delta T_a}$	Output Voltage Temperature Coefficient	-40℃≦T_a≦85℃			±100		ppm/℃
RR1	Ripple Rejection	f=1kHz, IOUT1=IOUT1max / 2			60		dB
EN1	Output Noise (RMS)	BW=100Hz-100kHz IOUT1=IOUT1max / 2			50		μVrms
ISS1	Supply Current	IOUT1=0mA			70		μA
IOFF1	Standby Current	IOUT1=0mA				1	μA
C_{OUT1}*2	Bypass Capacitor	0μA＜IOUT1＜200mA			2.2		μF
t_{r1}*3	Rising Time	IOUT1=0mA VO1＞VOUT1×90%			10		μs
t_{f1}	Falling Time	IOUT1=0mA VO1＜0.5V				500	μs

Table 8-4 LDO1 Electrical Characteristics

Note*1: The output voltage will be fixed (with 0.05V step) by trimming at shipment.

Note*2: Bypass capacitor: 2.2μF, in the mounted state.
For optimized phase compensation, the bypass capacitor must be ceramic type.

Note*3: When all regulators are off, the rising time will be added up with UVLO output delay time for releasing.
t_{r1} (Typ) = 10μs + 10μs (UVLO output delay time for releasing).

8.5 LDO2 Electrical Characteristics

Operating Conditions (unless otherwise specified) VIN1, VIN2, VIN3, PVIN = 3.6V, C_{OUT2} = 2.2μF, T_a = 25℃

Symbol	Parameter	Condition		Min	Typ	Max	Units
-	Input Voltage Range	VIN2 pin		1.746 (1.8-3%)		4.5	V
VOUT2*1	Output Voltage Range	-		1.2		3.3	V
IOUT2	Output Current	-				200	mA
VACC2	Output Voltage Accuracy	VOUT2+0.3V ≧1.746	VIN2=VOUT2+0.3V & IOUT2=IOUT2max, & VIN2=4.5V & IOUT2=50μA	-3		+3	%
		VOUT2+0.3V ＜1.746V	VIN2=1.746V & IOUT2=IOUT2max, & VIN2=4.5V & IOUT2=50μA				
ISHT2	Short Current	VO2=0V			120		mA
$\frac{\Delta VOUT2}{\Delta VIN}$	Line Regulation	VOUT2+0.3V ≧1.746	VOUT2+0.3V≦VIN2 ≦4.5V, IOUT2=IOUT2max /2			10	mV
		VOUT2+0.3V ＜1.746V	1.746V≦VIN2≦4.5V, IOUT2=IOUT2max /2				
$\frac{\Delta VOUT2}{\Delta IOUT2}$	Load Regulation	50μA＜IOUT2＜IOUT2max				30	mV
$\frac{\Delta VOUT2}{\Delta T_a}$	Output Voltage Temperature Coefficient	-40℃≦T_a≦85℃			±100		ppm/℃
RR2	Ripple Rejection	f=1kHz, IOUT2= IOUT2max / 2			60		dB
EN2	Output Noise (RMS)	BW=100Hz-100kHz IOUT2= IOUT2max / 2			50		μVrms
ISS2	Supply Current	IOUT2=0mA			70		μA
IOFF2	Standby Current	IOUT2=0mA				1	μA
C_{OUT2}*2	Bypass Capacitor	0μA＜IOUT2＜200mA			2.2		μF
t_{r2}*3	Rising Time	IOUT2=0mA VO2＞VOUT2×90%			10		μs
t_{f2}	Falling Time	IOUT2=0mA VO2＜0.5V				500	μs

Table 8-5

Table 8-6 LDO2 Electrical Characteristics

Note*1: The output voltage will be fixed (in 0.05V step) by trimming at shipment.

Note*2: Bypass capacitor: 2.2μF, in the mounted state.
For optimized phase compensation, the bypass capacitor must be ceramic type.

Note*3: When all regulators are off, the rising time will be added up with UVLO output delay time for releasing.
t_{r2}(Typ)= 10μs + 10μs(UVLO output delay time for releasing).

8.6 UVLO (Under Voltage Lock Out) Electrical Characteristics

Operating Conditions (unless otherwise specified) T_a = 25℃

Symbol	Parameter	Condition	Min	Typ	Max	Units
$V_{Release}$	Under voltage lock out threshold	VCCVIN rising		2.25		V
V_{Detect}	Under voltage lock out threshold	VCCVIN falling	2.05	2.20	2.35	V
V_{HYS}	UVLO Hysteresis	-		50		mV

Table 8-7 UVLO Electrical Characteristics

8.7 Thermal Shutdown Circuit Electrical Characteristics

Operating Conditions (unless otherwise specified) VIN1, VIN2, VIN3, PVIN = 3.6V

Symbol	Parameter	Condition	Min	Typ	Max	Units
T_{DET}	Detected Temperature	-		140		℃
T_{RET}	Return Temperature	-		110		℃

Table 8-8 Thermal Shutdown Circuit Electrical Characteristics

8.8 DC Electrical Characteristics

Operating Conditions (unless otherwise specified) VIN1, VIN2, VIN3, PVIN = 3.6V, T_a = 25℃

Symbol	Parameter	Condition	Min	Typ	Max	Units
VT+	"H" Input Rising Threshold Voltage (Schmitt)	DCON, LDO1ON, LDO2ON			1.6	V
VT-	"L" Input Rising Threshold Voltage (Schmitt)	DCON, LDO1ON, LDO2ON	0.4			V
V_{HIS}	Schmitt Hysteresis Voltage	DCON, LDO1ON, LDO2ON	0.1			V
I_{IL}	Input Leakage Current	DCON, LDO1ON, LDO2ON	-3		3	µA
I_{CCS}	Shutdown Supply Current (All output off)	VIN1~3, PVIN =4.5V, DCON=0V, LDO1ON=0V, LDO2ON=0V			1	µA
I_{CCD}	No Load Supply Current (All output on)	VIN1~3, PVIN =4.5V, DVOUT =1.8V DCON=3.6V, LDO1ON=3.6V, LDO2ON=3.6V IOUT1,IOUT2,DIOUT=0mA		210		µA

Table 8-9 DC Electrical Characteristics

Terminal Equivalent Circuit

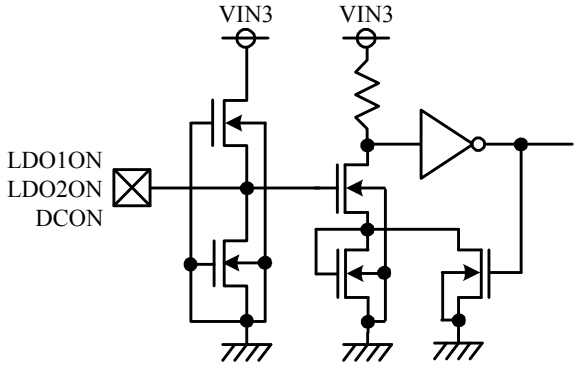


Fig 8-1 Terminal Equivalent Circuit

9. ON/OFF Control of LDOs and DC/DC

RN5T562 has two Low Drop Output regulators (LDOs) and DC/DC converter. LDOs and DC/DC converter are individually on/off controlled by each control pin; LDO1ON pin, LDO2ON pin and DCON pin.

The truth table is shown below.

State	LDO1ON	LDO2ON	DCON
ON	H	H	H
OFF	L	L	L

Table 9-1 ON/OFF Control of LDOs and DC/DC

10. Step-down DC/DC Converter

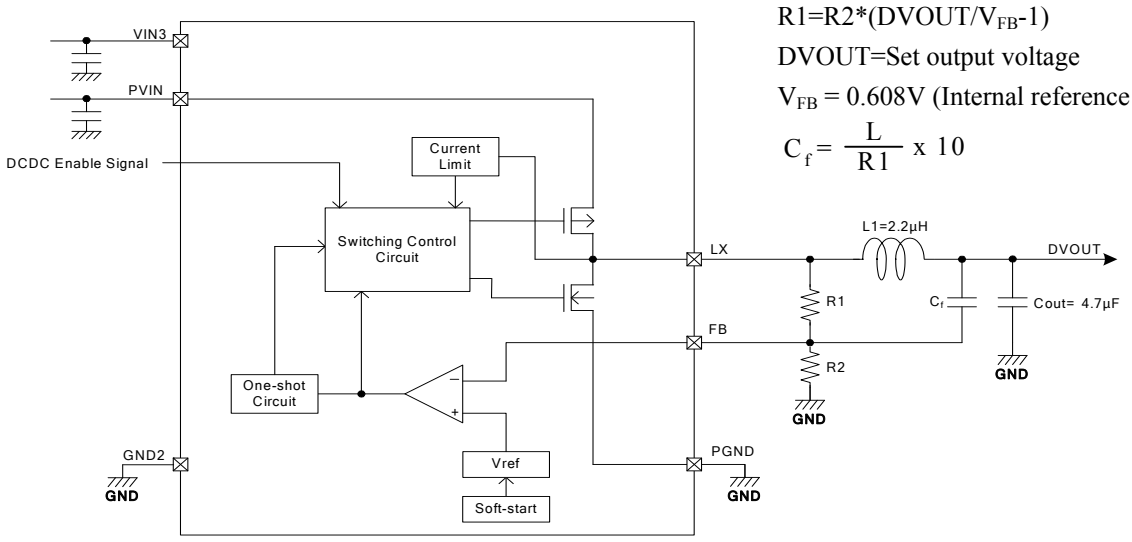
DC/DC converter turns on by DCON="H" (DC/DC enable signal). During standby mode, LX pin is high impedance. When DC/DC becomes active, the internal Soft-start circuit is enabled and output voltage starts boosting. RN5T562 compares the internal reference voltage (typ.0.608V) and FB voltage. If FB voltage is below the reference voltage, it turns on high-side switch by enabling one-shot circuit.

The high-side switch remains "ON" for the minimum-on-time and until FB voltage rises over the reference voltage, or inductor current exceeds limit current. Once the high-side switch is disabled, it remains off until FB voltage falls below the reference voltage, or inductor current falls below the limit current. During high-side switch is off, low-side switch remains on until inductor current approaches 0. DC/DC converter regulates the output voltage by repeating the above operation.

Therefore, oscillator frequency varies by input voltage, output voltage, output current and external circuit (R1, L, and Cf). In addition, the feedback loop from LX pin through R1 and from DVOUT through C_f eliminates phase lag, which is brought by the output capacitor, and the stable loop and fast transient response are provided.

However, the equivalent series resistance causes output voltage to shift by output current. (Theoretically, output voltage falls [IOUT(A)xDCR(Ω)])

10.1 Step-down DC/DC Converter Output Voltage Setting



$R1=R2*(DVOUT/V_{FB}-1)$

DVOUT=Set output voltage

V_{FB} = 0.608V (Internal reference voltage)

$$C_f = \frac{L}{R1} \times 10$$

Fig 10-1 Step-down DC/DC Converter Output Voltage Setting

External components example

- DVOUT=1.2V.
  R1=220kΩ, R2=220kΩ, C_f=100pF
- DVOUT=1.8V.
  R1=220kΩ, R2=110kΩ, C_f=100pF

11. Typical Application and Application Hints

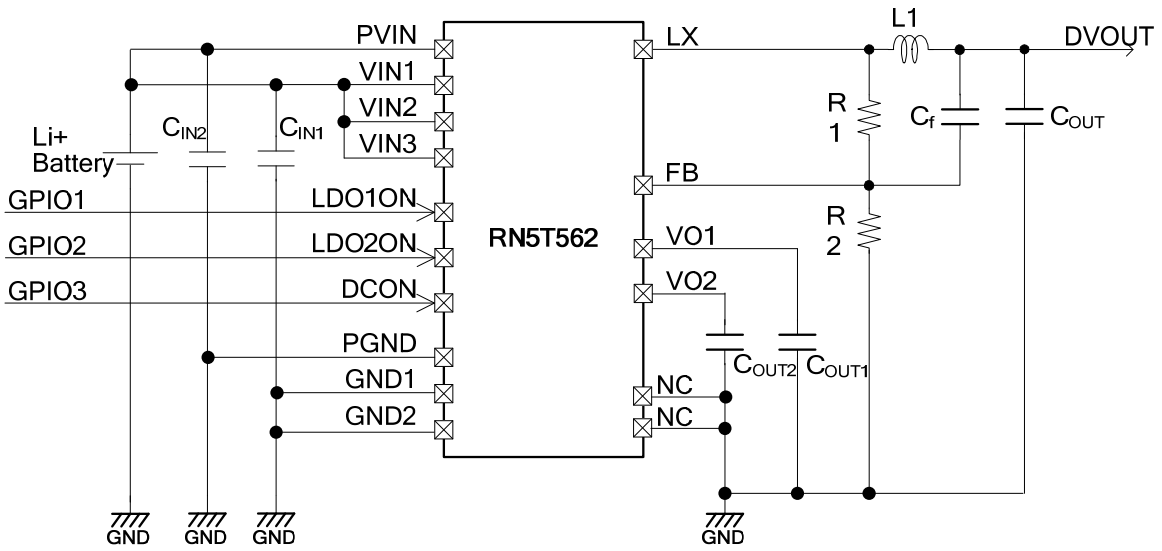


Fig 11-1 Typical Application and Application Hints

Symbol	Item
L1	2.2µH
R1	See section 9.1
R2	See section 9.1
C_f	See section 9.1
C_{OUT}	4.7µF Ceramic Capacitor
C_{OUT1}	2.2µF Ceramic Capacitor
C_{OUT2}	2.2µF Ceramic Capacitor
C_{IN1}	1.0µF Ceramic Capacitor
C_{IN2}	4.7µF Ceramic Capacitor

Table 11-1 Examples of Components

Vendor	Part number	Inductance [µH]	DCR [Ω]
FDK	MIPW3226D2R2M	2.2	0.1

Table 11-2 Recommended External Inductor

12. Appendix

12.1 Reference Data of Step-down DC/DC Converter

Operating Conditions VIN1, VIN2, VIN3, PVIN = 3.6V, T_a = 25℃ L1=2.2µH, C_{OUT}=4.7µF
L1: MIPW3226D2R2M (Vendor: FDK)
C_{OUT}: C1608JB0J475K (Vendor: TDK)

DVOUT = 1.8V: R1=220kΩ, R2=220kΩ, Cf =100pF
DVOUT = 1.2V: R1=220kΩ, R2=110kΩ, Cf =100pF

(1) Efficiency vs. Load Current

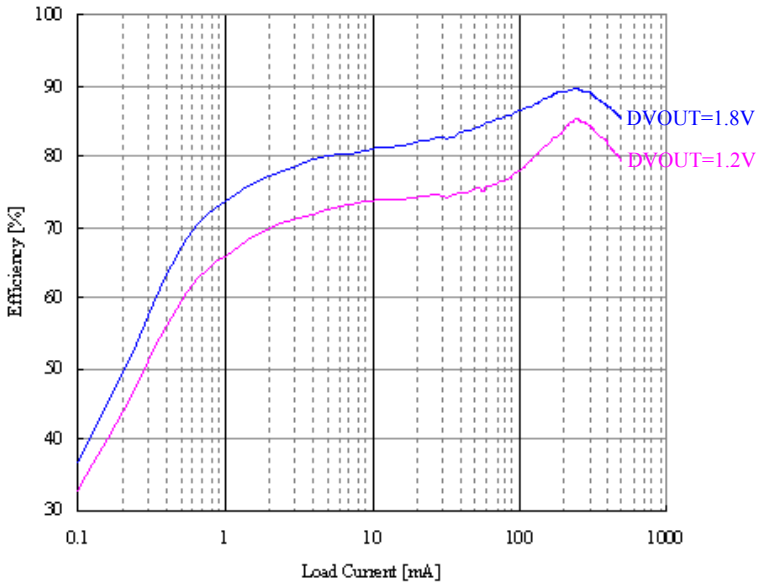


Fig 12-1 Efficiency vs. Load Current

(2) Output Voltage vs. Load Current

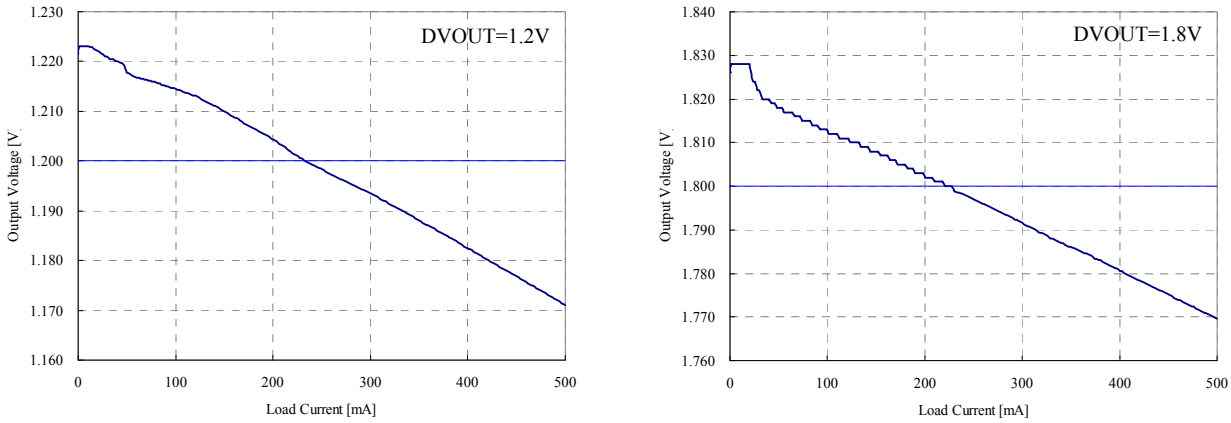


Fig 12-2 Output Voltage vs. Load Current

(3) Light Load Switching Waveforms

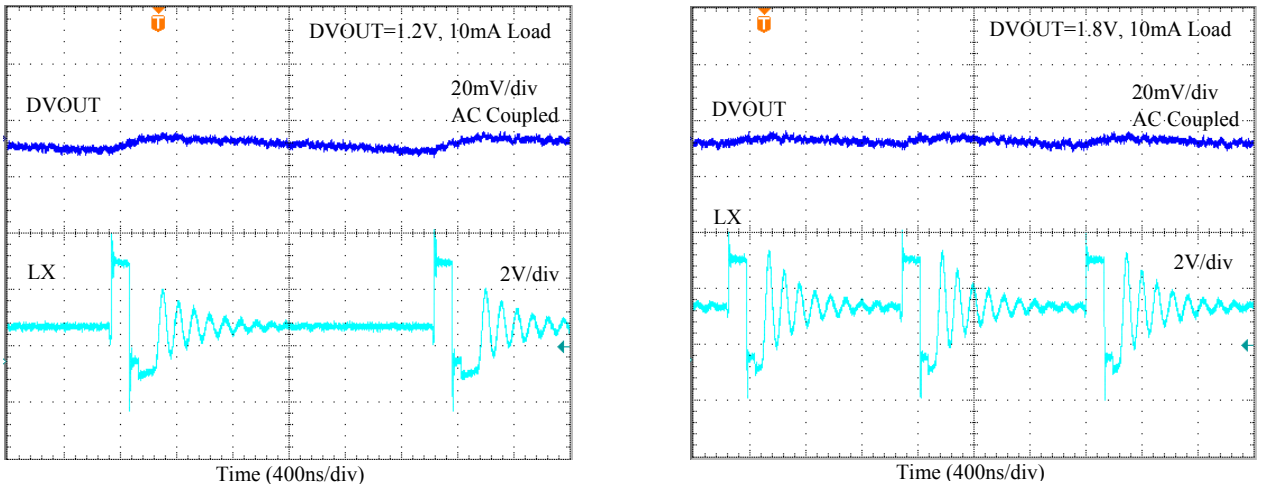


Fig 12-3 Light Load Switching Waveforms

(4) Heavy Load Switching Waveforms

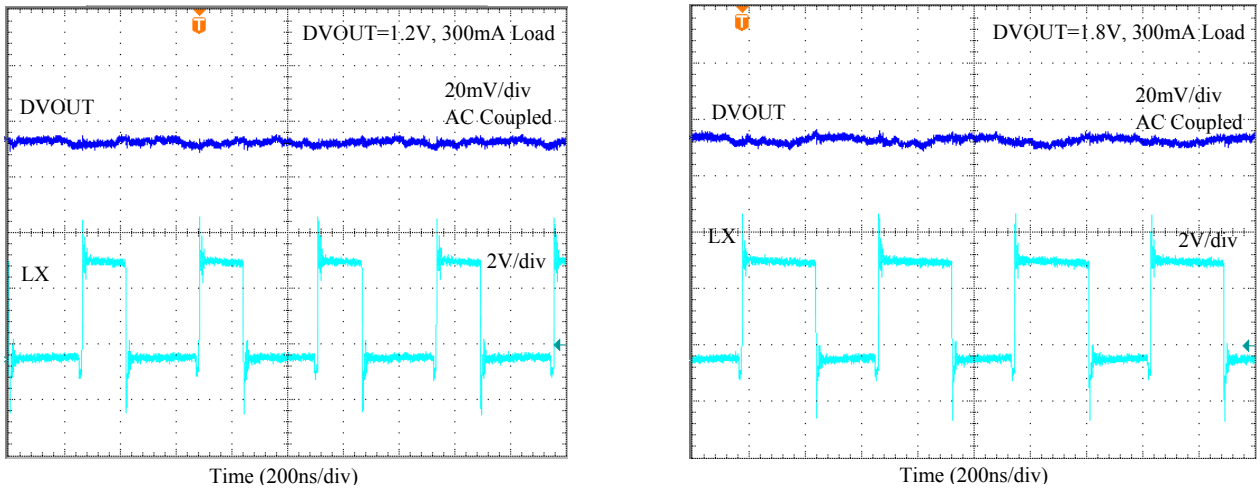


Fig 12-4 Heavy Load Switching Waveforms

(5) Load Transient Response

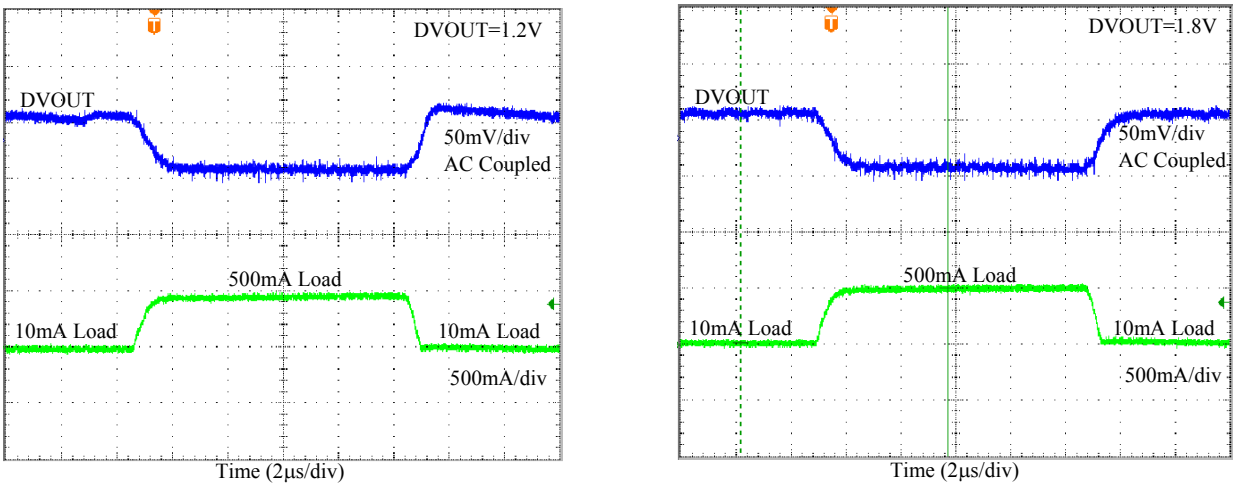


Fig 12-5 Load Transient Response

13. Package Information