

Quasi-Resonant type AC/DC converter IC

BM1Q0XX series Quasi-Resonant converter Technical Design

This application note describes the design of Quasi-Resonant converters using ROHM's AC/DC converter IC BM1Q0xx series devices. It explains the selection of external components and provides PCB layout guidelines. Please note that all performance characteristics have to be verified. They are not guaranteed by the PCB layout shown here.

• Description

The BM1Q0xx series of ICs are AC/DC converters for Quasi-Resonant switching, incorporating a built-in starter circuit having withstanding voltage of 650V. Use of external switching MOSFET and current detection resistors, provides a higher degree of design freedom. Power efficiency is improved by the built-in starter circuit and the reduction of switching frequency under light load conditions.

• Key features

- Quasi-resonant method
- Built-in 650V tolerate start circuit
- Low power when load is light (Burst operation)
- Maximum frequency control (120kHz)
- Frequency reduction function
- AC voltage correction function
- VCC pin : under voltage protection
- VCC pin : overvoltage protection
- Over-current protection (cycle-by-cycle)
- OUT pin : H voltage 12V clamp
- Soft start
- ZT trigger mask function
- ZT Over voltage protection
- FB Over Load protection [Auto-restart]
- CS pin open protection [Auto-restart]

• Basic specifications

Operating power supply voltage range(VCC)	: 8.9V to 26.0V
VH voltage range(VH pin)	: up to 600V
Operating current	: Normal mode 0.60 mA (Typ.)
	: Burst mode 0.35 mA (Typ.)
Maximum frequency	: 120 KHz (Typ.)
Operating temperature range	: -40°C to +85°C

• BM1Q0xx Series line-up

Product	Package	VCC OVP	ZT OVP
BM1Q001FJ	SOP-J8	Auto restart	None
BM1Q002FJ		Latch stop	Latch stop

• Applications

AC adapters, TVs, household appliances (vacuum cleaners, humidifiers, air filters, air conditioners, refrigerators, induction heating cookers, rice cookers, etc.)

1. Design Example of Isolated Type Quasi-Resonant Converter

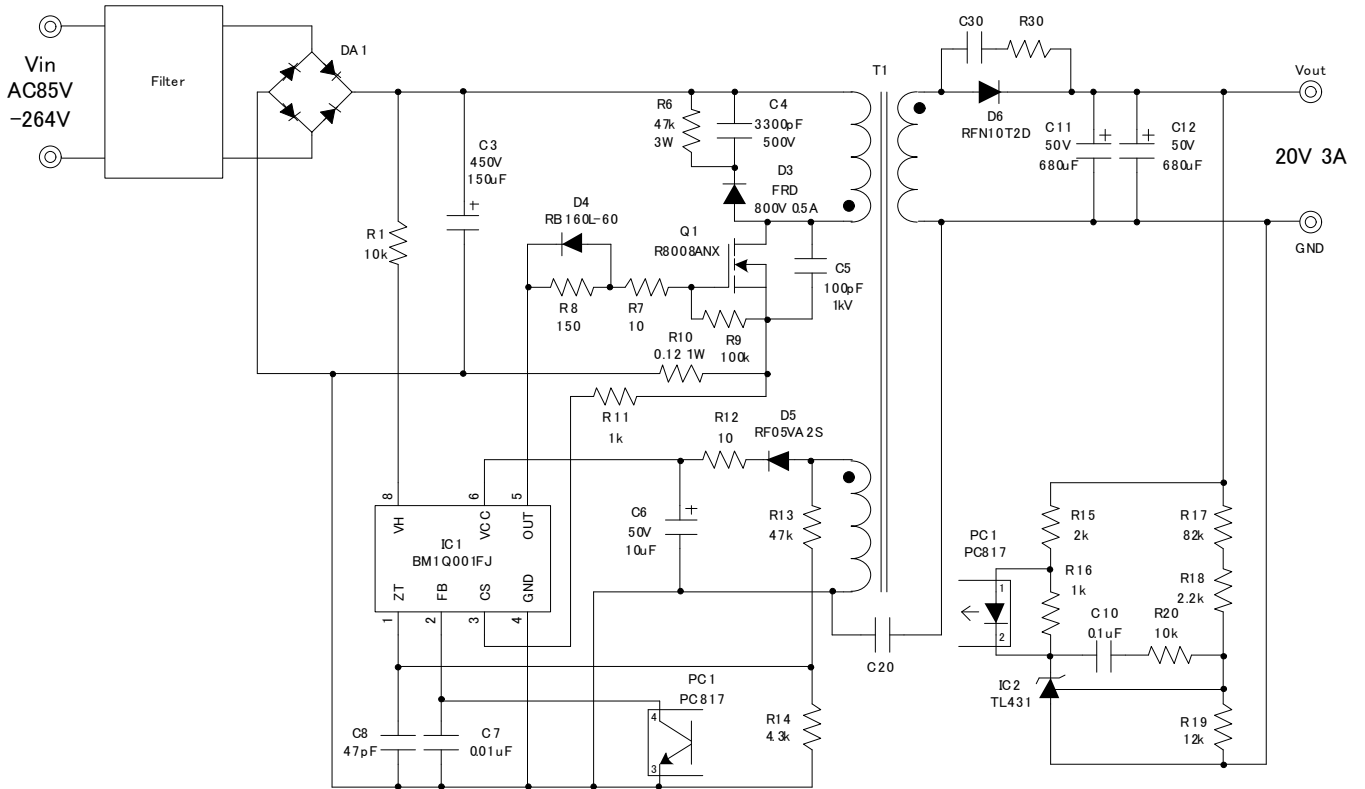


Figure 1-1. Isolated Type Quasi-Resonant Converter Circuit Example

Quasi-Resonant Converters become DCM (Discontinuous Conduction Mode) under light load, and switching frequency increases with the load increasing. When the load increased further, Quasi-Resonant Converters become BCM (Boundary Conduction Mode), and switching frequency decreases with the load increasing.

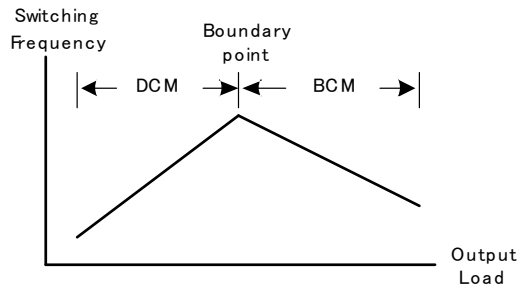


Figure 1-2. Switching Frequency – Output Load Characteristics

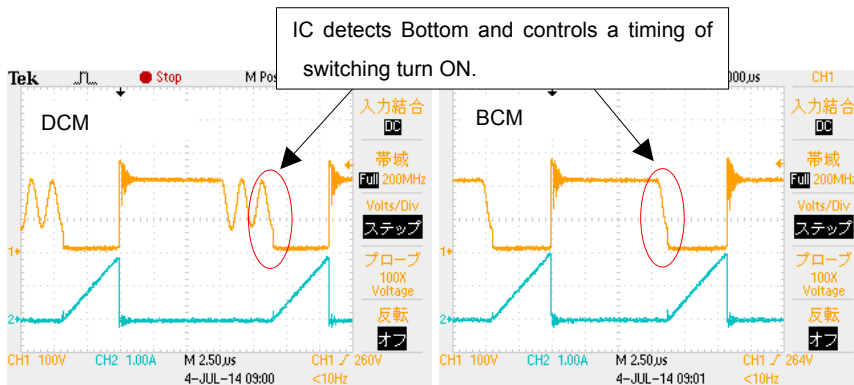


Figure 1-3. Switching waveform (MOSFET Vds, Ids)

1-1. Transformer T1 design

1-1-1. Determination of flyback voltage VOR

Flyback voltage VOR is determined along with turns-ratio Np:Ns and duty-ratio.

$$VOR = VO \times \frac{Np}{Ns} = \frac{ton}{toff} \times VIN$$

$$\Rightarrow \frac{Np}{Ns} = \frac{VOR}{VO}$$

$$\Rightarrow Duty = \frac{VOR}{VIN + VOR}$$

When VIN=95V (AC85Vx1.4x0.8), VOR=78V, Vf=1V:

$$\frac{Np}{Ns} = \frac{VOR}{VO} = \frac{VOR}{Vout + Vf} = \frac{78V}{20V + 1V} = 3.714$$

$$Duty(max) = \frac{VOR}{VIN(min) + VOR} = \frac{78V}{95V + 78V} = 0.45$$

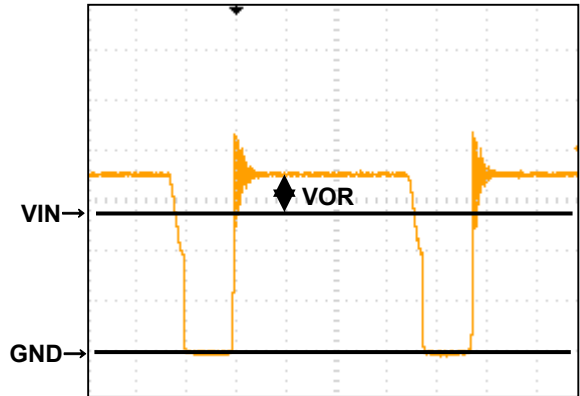


Figure 1-4. MOSFET Vds

(*) When duty is 0.5 or above, VOR is adjusted to set it below 0.5 in consideration of MOSFET's loss, etc.

1-1-2. Determination of Minimum frequency fsw and calculation of primary -side winding inductance Lp and primary-side maximum current Ippk

When VIN=95V, set minimum frequency to 38kHz.

Other's parameter is following:

Since of Po=20V x 3A=60W, Po(max)=70W in consideration of over current protection.

Transformer efficiency: η =90%

Resonance capacitor: Cv=100pF

$$Lp = \left[\frac{VIN(min) \times Duty(max)}{\sqrt{\frac{2 \times Po(max) \times fsw}{\eta} + VIN(min) \times Duty(max) \times fsw \times \pi \times \sqrt{Cv}}} \right]^2 = 297 \mu H$$

$$Ippk = \sqrt{\frac{2 \times Po(max)}{\eta \times Lp \times fsw}} = 3.713 A$$

1-1-3. Determination of transformer size

Based on Po(max)=70W, the transformer's core size is EER35.

Table 1-1. Output Voltage and Transformer Core

Output power Po(W)	Core size	Core sectional area Ae (mm ²)
~30	EI25/EE25	41
~60	EI28/EE28/EER28	84
~80	EI33/EER35	107

(*) The above are guideline values. For details, check with the transformer manufacturer, etc.

1-1-4. Calculation of primary-side turn count N_p

Generally, the maximum magnetic flux density $B(T)$ for an ordinary ferrite core is $0.4T @ 100^\circ C$, so $B_{sat} = 0.35T$.

$$N_p > \frac{L_p \times I_{ppk}}{A_e \times B_{sat}} = \frac{297\mu H \times 3.713A}{107mm^2 \times 0.35T} = 29.4 \text{ turns} \rightarrow N_p \text{ is 30 turns or above}$$

Since magnetic saturation does not result from this, N_p is set based on the AL-value—NI characteristics.

When $N_p=30$ turns,

$$AL - \text{Value} = \frac{L_p}{N_p^2} = \frac{297\mu H}{30\text{turns}^2} = 330\text{nH} / \text{turns}^2$$

$$NI = N_p \times I_{ppk} = 30\text{turns} \times 3.713A = 111.4A \cdot \text{turns}$$

In this case, transformer is saturated based on the AL-value—NI characteristics.

When $N_p=40$ turns,

$$AL - \text{Value} = \frac{L_p}{N_p^2} = \frac{297\mu H}{40\text{turns}^2} = 186\text{nH} / \text{turns}^2$$

$$NI = N_p \times I_{ppk} = 40\text{turns} \times 3.713A = 148.5A \cdot \text{turns}$$

In this case, this point is within the tolerance range.

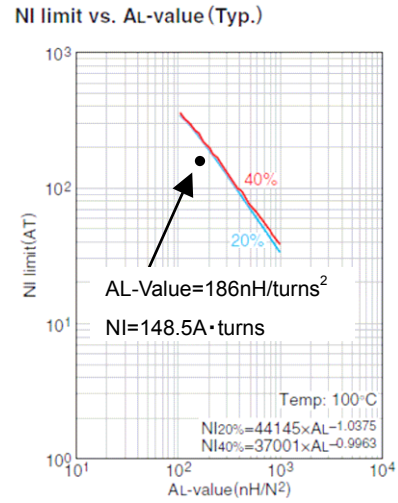


Figure 1-5. TDK PC47EER35-Z AL-Value—NI Limit Characteristics

1-1-5. Calculation of secondary-side turn count N_s

$$\frac{N_p}{N_s} = 3.714 \rightarrow N_s = \frac{40}{3.714} = 10.8 \text{ turns} \rightarrow 11 \text{ turns}$$

1-1-6. Calculation of VCC turn count N_d

When $V_{CC}=15V$, $V_{f_vcc}=1V$,

$$N_d = N_s \times \frac{V_{CC} + V_{f_vcc}}{V_{out} + V_f} = 11\text{turns} \times \frac{15V + 1V}{20V + 1V} = 8.8\text{turns} \rightarrow 9 \text{ turns}$$

As a result, the transformer specifications are as follows.

Table 1-2. Transformer Specifications

Core	TDK PC47EER35-Z or compatible
L_p	297 μH
N_p	40 turns
N_s	11 turns
N_d	9 turns

1-2. Selection of main components

1-2-1. MOSFET: Q1

Factors to select a MOSFET include the maximum drain-source voltage, peak current, loss due to Ron, and the package's maximum allowable loss.

In particular, in the case of world-wide input (AC 85V to AC264 V, etc.), the MOSFET's ON-period becomes long when the input voltage is low, and Ron-loss makes more heat generated. Confirm while the MOSFET is assembled in the product, and, when necessary, use a heat-sink or similar to dissipate the heat.

In this design example, ROHM's MOSFET R8008ANX (800V, 8A, 0.79Ω) is selected based on worldwide input and Ippk = 3.713A.

1-2-2. Input capacitor: C3

Use Table 1-3 to select the capacitance of the input capacitor.

Since Pout=20Vx3A=60W, C1=2x60=120 → 150uF.

Table 1-3. Input Capacitor Selection Table

Input voltage (Vac)	Cin(uF)
85-264	2 x Pout(W)
180-264	1 x Pout(W)

(*) The above values are guidelines for full-wave rectification.

When selecting, also consider other specifications such as the retention-time.

The withstanding voltage of the capacitor becomes, Vac (max) × 1.41. Say for AC 264V, it is 264V × 1.41 = 372V, so this should be 400V or more.

1-2-3. Setting resistor for changing of over current protection point:R13

When input voltage is high, ON time is short, and switching frequency increases. As a result, maximum output power increases for constant over current limiter. For that, monitoring input voltage, IC switches CS over current voltage level when ZT input current: Izt=1mA.

Set input voltage to AC150V→DC212V when over current protection point changes.

$$R13 = VIN(\text{change}) \times \frac{Nd}{Np} \times \frac{1}{Izt} = 212V \times \frac{9\text{turns}}{40\text{turns}} \times \frac{1}{1\text{mA}} = 47.7k\Omega \rightarrow 47k\Omega$$

1-2-4. Setting resistor for ZT terminal voltage:R14

ZT bottom detected voltage is Vz1=100mV(typ.)(ZT fall), Vz2=200mV(typ.)(ZT rise), and ZT OVP(min) is 4.65V (BM1Q002FJ), so as a guide, set Vz to 1V to 3V.

$$Vzt = (Vout + Vf) \times \frac{Nd}{Ns} \times \frac{R14}{R13 + R14} = 1.5V \quad R14 = 4.495k\Omega \rightarrow 4.3k\Omega$$

1-2-5. Current-sensing resistor: R10

The current-sensing resistor limits the current that flows on the primary side to provide protection against output overload.

$$R10 = \frac{V_{cs}}{I_{ppk}} = \frac{0.5V}{3.713A} = 0.135\Omega \rightarrow 0.12\Omega$$

Check over current protection point after it was changed.

When IC switches CS over current voltage level, it is changed from 0.5V to 0.35V.

$$V_{IN}(\text{change}) = R13 \times \frac{N_p}{N_d} \times I_{zt} = 47k\Omega \times \frac{40\text{turns}}{9\text{turns}} \times 1mA = 209V$$

$$I_{ppk}' = \frac{V_{cs}}{R10} = \frac{0.35V}{0.12\Omega} = 2.917A$$

$$t_{on}' = \frac{L_p \times I_{ppk}'}{V_{IN}(\text{change})} = \frac{297\mu H \times 2.917A}{209V} = 4.145\mu s$$

$$I_{spk}' = \frac{N_p}{N_s} \times I_{ppk}' = \frac{40\text{turns}}{11\text{turns}} \times 2.917A = 10.61A$$

$$L_s = L_p \times \left(\frac{N_s}{N_p}\right)^2 = 297\mu H \times \left(\frac{11\text{turns}}{40\text{turns}}\right)^2 = 22.46\mu H$$

$$t_{off}' = \frac{L_s \times I_{spk}'}{V_{out} + V_f} = \frac{22.46\mu H \times 10.61A}{20V + 1V} = 11.35\mu s$$

$$t_{delay} = \pi \times \sqrt{L_p \times C_v} = 3.14 \times \sqrt{297\mu H \times 100pF} = 0.541\mu s$$

$$f_{sw}' = \frac{1}{t_{on}' + t_{off}' + t_{delay}} = \frac{1}{4.145\mu s + 11.35\mu s + 0.541\mu s} = 62.36kHz$$

Transformer efficiency: $\eta = 90\%$

$$P_{o'} = \frac{1}{2} \times L_p \times I_{ppk}'^2 \times f_{sw}' \times \eta = \frac{1}{2} \times 297\mu H \times 2.917A^2 \times 62.36kHz \times 0.9 = 70.92W$$

When $P_{o'}$ is under the rated output power, $V_{IN}(\text{change})$, R10, etc. are adjusted to set $P_{o'}$ above rated output power.

Confirm the overload protection point while the resistor is assembled in the product.

Sensing resistor loss P_{R10} :

$$P_{R10}(\text{peak}) = I_{ppk}'^2 \times R10 = 3.713A^2 \times 0.12\Omega = 1.654W$$

$$P_{R10}(\text{rms}) = I_{rms}^2 \times R10 = \left(I_{ppk}' \times \sqrt{\frac{\text{Duty}(\text{max})}{3}} \right)^2 \times R10 = \left(3.713A \times \sqrt{\frac{0.45}{3}} \right)^2 \times 0.12 = 0.248W$$

Set to 1W or above in consideration of pulse resistance.

With regard to pulse resistance, the structure of the resistance may vary even with the same power rating.

Check with the resistor manufacturers for details.

1-2-6. VCC-diode: D5

A high-speed diode is recommended as the VCC-diode.

When $D5_Vf=1V$, reverse voltage applied to the VCC-diode:

$$V_{dr} = V_{CC}(\text{max}) + V_f + V_{IN} \text{max} \times \frac{N_d}{N_p}$$

When $V_{CC}(\text{max}) = 29V$,

$$V_{dr} = 29V + 1V + 372V \times \frac{9\text{turns}}{40\text{turns}} = 113.7V$$

With a design-margin taken into account, $122.5V / 0.7 = 175V \rightarrow 200V$ component is selected.

(Example: ROHM's RF05VA2S 200V, 0.5A)

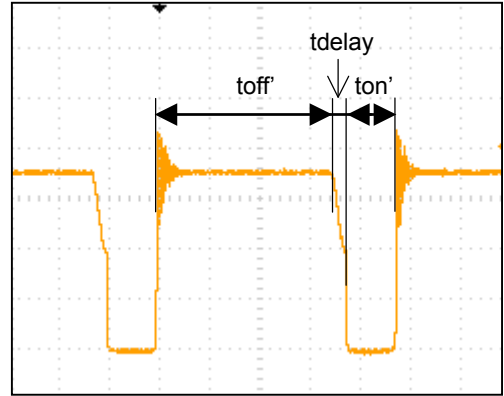


Figure 1-6. Switching waveform

1-2-7. VCC capacitor: C6

A VCC capacitor is needed to stabilize the IC's VCC voltage.

Capacitance of 2.2μF or above is recommended

(example: 50V, 10μF).

Next, determine the startup time of the IC at power-on.

Figure 1-7 illustrates VCC capacitor capacitance and startup time characteristics.

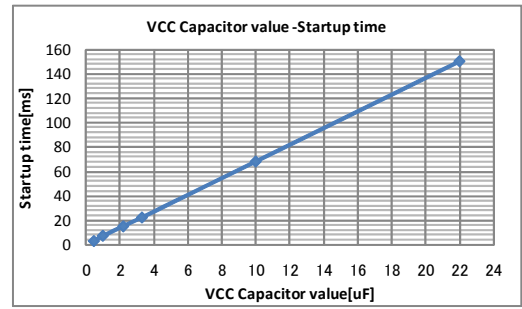


Figure 1-7. Startup Time (Reference Values)

1-2-8. VCC winding surge-voltage limiting resistor: R12

Based on the transformer's leakage inductance (Lleak), a large surge-voltage (spike noise) may occur during the instant when the MOSFET is switched from ON to OFF. This surge-voltage is induced in the VCC winding, and as the VCC voltage increases the IC's VCC overvoltage protection may be triggered.

A limiting resistor R2 (approximately 5Ω to 22Ω) is inserted to reduce the surge-voltage that is induced in the VCC winding. Confirm the rise in VCC voltage while the resistor is assembled in the product.

1-2-9. Snubber circuits: C4,D3,R6

Based on the transformer's leakage inductance (Lleak), a large surge-voltage (spike noise) may occur during the instant when the MOSFET is switched from ON to OFF. This surge-voltage is applied between the MOSFET's Drain and Source, so in the worst case damage to MOSFET might occur. RCD snubber circuits are recommended to suppress this surge-voltage.

(1) Determination of clamp voltage (Vclamp) and clamp ripple-voltage (Vripple)

Take a design-margin based on the MOSFET's withstand voltage for the clamp voltage.

$$V_{clamp} = 800V \times 0.8 = 640V$$

The clamp ripple-voltage (Vripple) is about 50V.

(2) Determination of R6

$$R6 < 2 \times V_{clamp} \times \frac{V_{clamp} - V_{OR}}{L_{leak} \times I_p^2 \times f_{sw(max)}}$$

Calculation of Ip, fsw when Lleak = Lp × 10% = 297μH × 10% = 29.7μH, Po=60W and VIN(max)=372V.

$$P_o = \frac{1}{2} \times L_p \times I_p^2 \times f_{sw} \times \eta$$

$$I_p = \frac{V_{cs}}{R_{cs}} \quad f_{sw} = \frac{1}{t_{on} + t_{off} + t_{delay}} = \frac{1}{\left(\frac{L_p}{V_{IN}} \times I_p\right) + \left(\frac{L_s}{V_o + V_f} \times \frac{N_p}{N_s} \times I_p\right) + \pi \times \sqrt{L_p \times C_v}}$$

$$\Rightarrow V_{cs}=0.2657V, I_p=2.214A, f_{sw}=91.6kHz$$

R6 is derived as:

$$R6 < 2 \times 640V \times \frac{640V - 76.4V}{29.7\mu H \times 2.214^2 \times 91.6kHz} = 54k \Omega \rightarrow 47k \Omega$$

R6 loss P_R6 is expressed as

$$P_{R6} = \frac{(V_{clamp} - V_{IN})^2}{R6} = \frac{(640 - 372)^2}{47k \Omega} = 1.53W$$

A 3W component is determined with consideration for design margin.

(3) Determination of C4

$$C4 > \frac{V_{clamp}}{V_{ripple} \times f_{sw}(\min) \times R4} = \frac{640V}{50V \times 91.6kHz \times 47k \Omega} = 2973pF \rightarrow 3300pF$$

The voltage applied to C4 is 640V – 264×1.41 = 268V.

Set 400V or above with design margin.

(4) Determination of D3

Choose a fast recovery diode as the diode, with a withstanding voltage that is at or above the MOSFET's Vds (max) value.

The surge-voltage affects not only the transformer's leakage inductance but also the PCB substrate's pattern.

Confirm the Vds voltage while assembled in the product, and adjust the snubber circuit as necessary.

1-2-10. Output rectification diode: D6

Choose a high-speed diode (Schottky barrier diode or fast recovery diode) as the output rectification diode.

When D6_Vf=1V, reverse voltage applied to output diode is

$$V_{dr} = V_{out(max)} + V_f + V_{INmax} \times \frac{N_s}{N_p}$$

When Vout(max)=20V+5%=21V:

$$V_{dr} = 21V + 1V + 372V \times \frac{11}{40} = 124.3V$$

A 124.3V/0.7=178V → 200V component is determined with consideration for design margin.

Also, diode loss (approximate value) becomes Pd = Vf × Iout = 1V × 3A = 3W.

(Example: Rohm RFN10T2D: 200V, 10A, TO-220F package)

Use of a voltage margin of 70% or less and current of 50% or less is recommended.

Check temperature rise while assembled in the product. When necessary, reconsider the component and use a heat sink or similar to dissipate the heat.

1-2-11. Output capacitors: C11, C12

Determine the output capacitors based on the output load's allowable peak-to-peak ripple voltage (ΔVpp) and ripple-current.

When the MOSFET is ON, the output diode is OFF. At that time, current is supplied to the load from the output capacitors.

When the MOSFET is OFF, the output diode is ON. At that time, the output capacitors are charged and a load current is also supplied.

When ΔVpp = 200mV,

$$Z_C < \frac{\Delta V_{pp}}{I_{spk}} = \frac{\Delta V_{pp}}{\frac{N_p}{N_s} \times I_{ppk}} = \frac{0.2V}{\frac{40}{11} \times 3.713A} = 0.0148 \Omega \quad \text{at } 60kHz (f_{sw} \min)$$

With an ordinary switching power supply electrolytic-capacitor (low-impedance component), impedance is rated at 100kHz, so it is converted to 100kHz.

$$Z_C < 0.0148 \Omega \times \frac{60}{100} = 0.009 \Omega \quad \text{at } 100kHz$$

Ripple-current Is (rms):

$$I_s(\text{rms}) = I_{spk} \times \sqrt{\frac{1 - \text{Duty}}{3}} = \frac{40}{11} \times 3.713A \times \sqrt{\frac{1 - 0.45}{3}} = 5.781A$$

The capacitor's withstanding voltage should be set to about twice the output voltage.

Vout × 2 = 20V × 2 = 40V → 50V or above

Select an electrolytic capacitor that is suitable for these conditions.

(Example: low impedance type 35V, 1000 μF × 2 parallel for switching power supply)

(*) Use the actual equipment to confirm the actual ripple-voltage and ripple-current.

1-2-12. MOSFET gate circuits: R7,R8,D4

The MOSFET's gate circuits affect the MOSFET's loss and generate noise. The Switching speed for turn-on is adjusted using R7+R8, and for turn-off is adjusted using R7, via the drawing diode D4.

(Example: R7: 10Ω/ 0.25W, R8: 150Ω, D4: SBD 60V, 1A)

In the case of Quasi-Resonant converters, switching-loss basically does not occur during turn-on, but occurs predominantly during turn-off. To reduce switching-loss when turned off, turn-off speed can be increased by reducing R7 value, but sharp changes in current will occur, which increases the switching-noise. Since there is a trade-off between loss (heat generation) and noise, measure the MOSFET's temperature rise and noise while it is assembled in the product, and adjust it as necessary.

Also, since a pulse current flows to R7, check the pulse resistance of the resistors being used.

1-2-13. FB terminal capacitor: C7

C7 is a capacitor for stability of FB voltage (approximately 1000pF to 0.01uF).

1-2-14. ZT terminal capacitor: C8

C8 is a capacitor for stability of ZT voltage and for timing adjustment of bottom detection.

Check the waveform of ZT terminal and the timing of bottom detection, and adjust it as necessary.

1-2-15. Output voltage setting resistors: R17, R18, R19

When Shunt regulator IC2:Vref=2.495V,

$$V_o = \left(1 + \frac{R17 + R18}{R19}\right) \times V_{ref} = \left(1 + \frac{82\text{ k}\Omega + 2.2\text{ k}\Omega}{12\text{ k}\Omega}\right) \times 2.495\text{ V} = 20.00\text{ V}$$

1-2-16. Parts for adjustment of control circuit: R15, R16, R20, C10

R20 and C10 are parts for phase compensation. Approximately R20:1k to 30kΩ, C10=0.1uF, and adjust them while they are assembled in the product.

R15 limits a control circuit current. Approximately R15:300 to 2kΩ, and adjust it while it assembled in the product.

R16 is a resistor for adjustment of minimum operating current of shunt regulator IC2.

In case of IC2: TL431, minimum operating current is 1mA. And when Optocoupler:PC1_Vf is 1V,

$$R16 = 1\text{ V} / 1\text{ mA} = 1\text{ k}\Omega$$

1-3. EMI countermeasures

Confirm the following with regard to EMI countermeasures.

(*) Constants are reference values. Need to be adjusted based on noise effects.

- Addition of filter to input block
- Addition of capacitor between primary-side and secondary-side (approximately C20: Y-Cap 2200pF)
- Addition of RC snubber to diode (approximately C30: 500V 1000pF, R30: 10Ω, 1W)

1-4. Output noise countermeasures

As an output noise countermeasure, add an LC filter (approximately L:10μH, C: 10μF to 100μF) to the output.

(*) Constants are reference values.

Need to be adjusted based on noise effects.

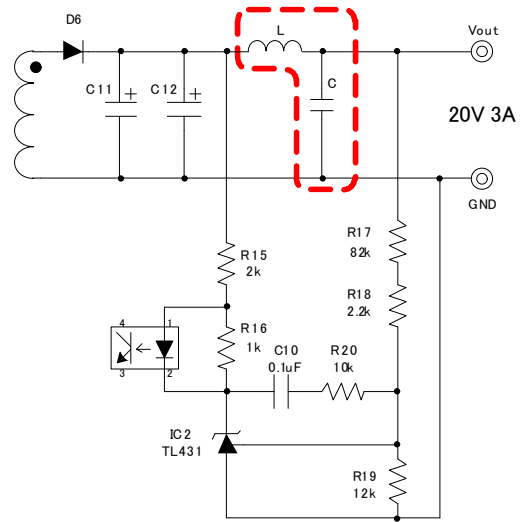


Figure 1-8. LC Filter Circuit

1-5. Proposed PCB layout

A proposed layout (example) for these circuits is shown in Figure 1-9.

- Single-sided board, lead component view
- Components in red are surface-mounted components

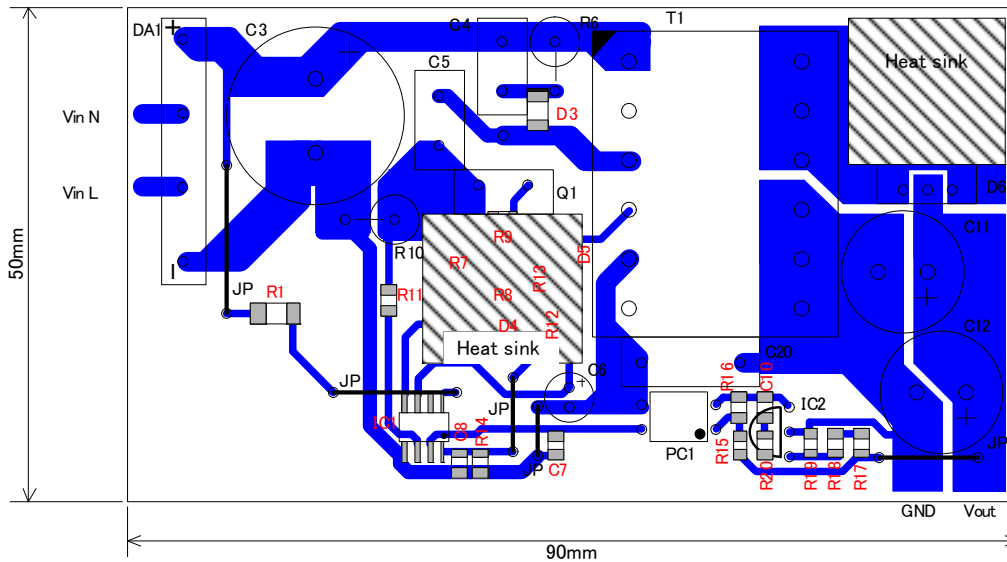


Figure 1-9. Proposed PCB Layout (Example)

Notes

- 1) The information contained herein is subject to change without notice.
- 2) Before you use our Products, please contact our sales representative and verify the latest specifications :
- 3) Although ROHM is continuously working to improve product reliability and quality, semiconductors can break down and malfunction due to various factors.
Therefore, in order to prevent personal injury or fire arising from failure, please take safety measures such as complying with the derating characteristics, implementing redundant and fire prevention designs, and utilizing backups and fail-safe procedures. ROHM shall have no responsibility for any damages arising out of the use of our Products beyond the rating specified by ROHM.
- 4) Examples of application circuits, circuit constants and any other information contained herein are provided only to illustrate the standard usage and operations of the Products. The peripheral conditions must be taken into account when designing circuits for mass production.
- 5) The technical information specified herein is intended only to show the typical functions of and examples of application circuits for the Products. ROHM does not grant you, explicitly or implicitly, any license to use or exercise intellectual property or other rights held by ROHM or any other parties. ROHM shall have no responsibility whatsoever for any dispute arising out of the use of such technical information.
- 6) The Products are intended for use in general electronic equipment (i.e. AV/OA devices, communication, consumer systems, gaming/entertainment sets) as well as the applications indicated in this document.
- 7) The Products specified in this document are not designed to be radiation tolerant.
- 8) For use of our Products in applications requiring a high degree of reliability (as exemplified below), please contact and consult with a ROHM representative : transportation equipment (i.e. cars, ships, trains), primary communication equipment, traffic lights, fire/crime prevention, safety equipment, medical systems, servers, solar cells, and power transmission systems.
- 9) Do not use our Products in applications requiring extremely high reliability, such as aerospace equipment, nuclear power control systems, and submarine repeaters.
- 10) ROHM shall have no responsibility for any damages or injury arising from non-compliance with the recommended usage conditions and specifications contained herein.
- 11) ROHM has used reasonable care to ensure the accuracy of the information contained in this document. However, ROHM does not warrant that such information is error-free, and ROHM shall have no responsibility for any damages arising from any inaccuracy or misprint of such information.
- 12) Please use the Products in accordance with any applicable environmental laws and regulations, such as the RoHS Directive. For more details, including RoHS compatibility, please contact a ROHM sales office. ROHM shall have no responsibility for any damages or losses resulting from non-compliance with any applicable laws or regulations.
- 13) When providing our Products and technologies contained in this document to other countries, you must abide by the procedures and provisions stipulated in all applicable export laws and regulations, including without limitation the US Export Administration Regulations and the Foreign Exchange and Foreign Trade Act.
- 14) This document, in part or in whole, may not be reprinted or reproduced without prior consent of ROHM.



Thank you for your accessing to ROHM product informations.
More detail product informations and catalogs are available, please contact us.

ROHM Customer Support System

<http://www.rohm.com/contact/>