Power IC BIC1421

<Summary>

BIC1421 is a high efficiency POWER-IC of MCM (multi chip module) with synchronous rectification system chopper control, N channel MOSFET of main switch and low side MOSFET for synchronous rectification. Maximum output is 3A and the input voltage range corresponds to 8V-40V which covers the input voltage of IEEE-1394. The functions such as over-current protection, over-heat protection and ON/OFF control etc. are all put in the surface mount one-package IC, which makes it possible to achieve a small size and light DC-DC converter with very few external components.

<Features>

- Input voltage range which corresponds to IEEE-1394: (DC8-40V)
- Switchable output voltage: 3.3V/ 5.0V
- Maximum output current: 3.0A
- Built-in main switch MOSFET and commutation MOSFET
- Over-current protection
- Over-heat protection
- Remote ON/ OFF control
- Lead-free correspondence

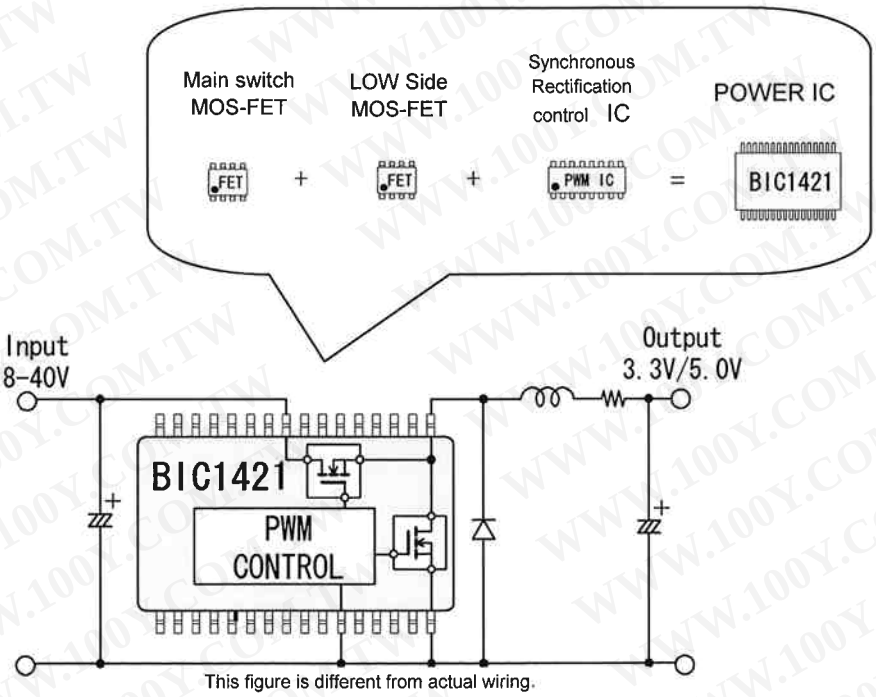
< Applications >

- Information distribution equipment
- Office automation equipment
- Electronic measuring instruments
- Home appliances
- Telecommunications equipment
- Factory automation equipment (Process control)
- Audio-Video devices

< Designation of product >

Model name: BIC1421

The packaging, only tape and reel is available.



This figure is different from actual wiring.

<Absolute maximum rating (Ta=25°C)>

Item	Symbol	Rating	Unit
Line voltage	Vin	42	V
Output MOS input voltage	Vdd	42	V
Output current (AVE)	Iout ave	3	A
Output current (PEAK)	Iout peak	4	A
Remote control voltage	VRC	5.5	V
Storage temperature	Tstg	-40 to 150	°C
Junction temperature	Tj	150	°C

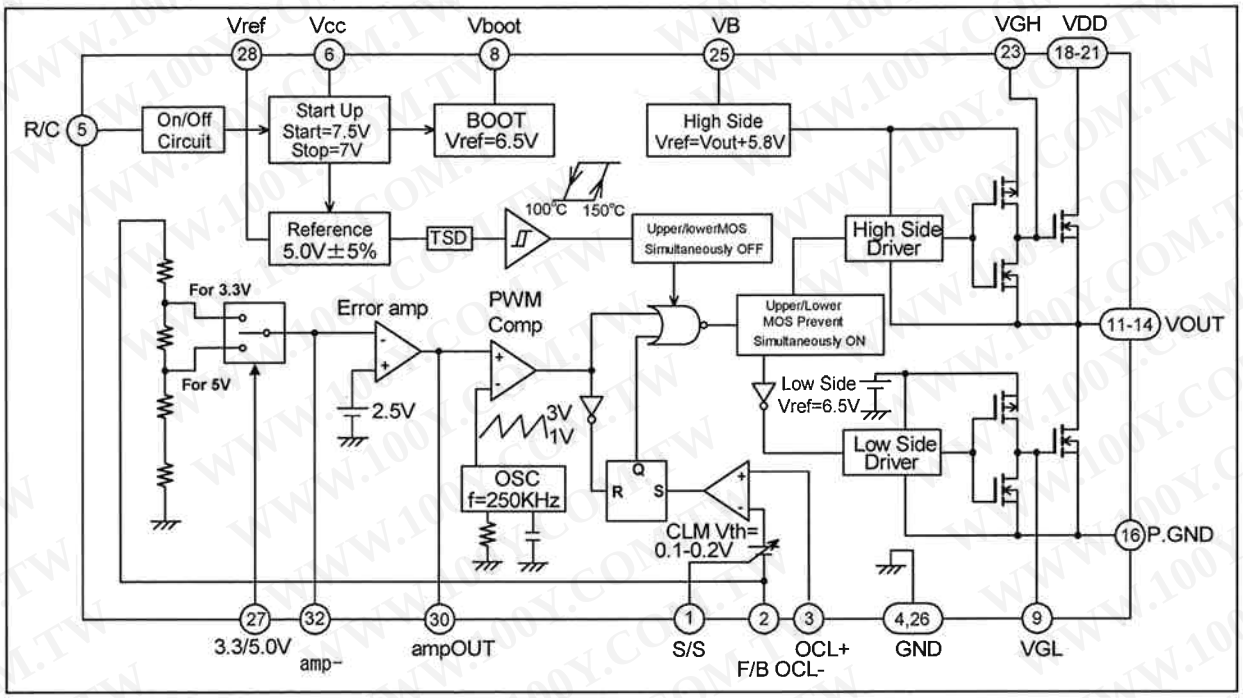
<Electrical charateristics (Ta=25°C)>

Item	Symbol	Conditions	MIN	TYP	MAX	Unit
HighsideMOS Drain-source breakdown voltage	Vdss	Id=1mA,Vgs=0V	42	—	—	V
HighsideMOS Drain interruption current	Idss	Vds=40V,Vgs=0V	—	—	10	μA
HighsideMOS Drain-source ON resistance	Ron	Id=1.2A,Vgs=4.5V	—	33	70	mΩ
HighsideMOS Source-drain Di forward voltage	Vsd	Is=1.2A,Vgs=0V	—	—	1.5	V
LowSideMOS Drain-source breakdown voltage	Vdss	Id=1mA,Vgs=0V	42	—	—	V
LowSideMOS Drain interruption current	Idss	Vds=40V,Vgs=0V	—	—	10	μA
LowSideMOS Drain-source ON resistance	Ron	Id=1.2A,Vgs=4.5V	—	33	70	mΩ
LowSideMOS Source-drain breakdown voltage	Vsd	Is=1.2A,Vgs=0V	—	—	1.5	V
Start voltage	Vcc_start	—	7	7.5	8	V
Stop voltage	Vcc_stop	—	6.5	7	7.5	V
Start-stop voltage hysteresis	Vcc_hys	—	—	0.5	—	V
Current consumption	Icc	Vcc=8V-40V	—	10	12	mA
Current consumption with remote control OFF	Icc_off	Vcc=8V-40V	—	1.2	1.5	mA
Voltage with remote control terminal ON	Vrc_on	Vcc=8V-40V	-0.2	—	0.5	V
Voltage with remote control terminal OFF	Vrc_off	Vcc=8V-40V	2.5	—	5.3	V
Current with remote control terminals shorted	Irc	Vcc=8V-40V	—	—	250	μA
Boot terminal voltage	Vboot	Vcc=24V	6	6.5	7	V
Internal reference voltage	Vref	Vcc=8V-40V	4.75	5	5.25	V
Internal oscillation frequency	fosc	Vcc=24V	212.5	250	287.5	kHz
Over-current threshold voltage	Vth_OCL	Vcc=24V	0.162	0.19	0.218	V
Soft-start terminal current	Is/s	Vcc=24V	-20	-12.5	-5	μA
"H" CHG terminal input voltage	Vchgh	—	4.5	—	Vref	V
"L" CHG terminal input voltage	Vchgl	—	GND	—	0.5	V
Over-current protection operating temperature	T_TSD	—	—	150	—	° C

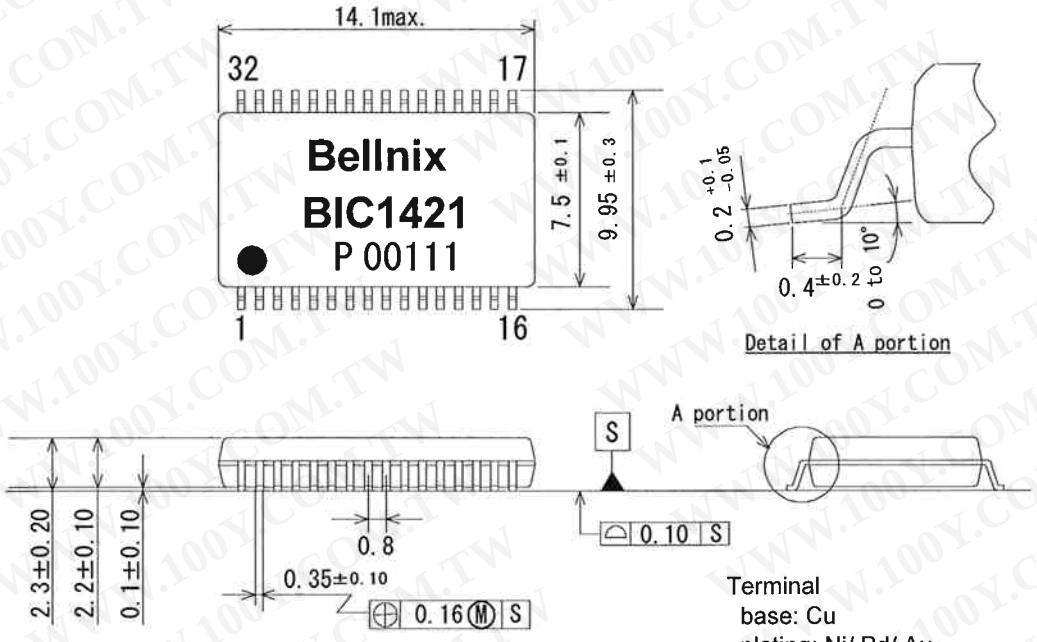
<Recommended operating conditions>

Item	Recommended Value	Unit
Input voltage (Ta=-10 to +85°C)	8.0 to 40	V
Input voltage (Ta=-30 to -10°C)	8.5 to 40	V
Operating temperature	-30 to 85	°C

<Block diagram>



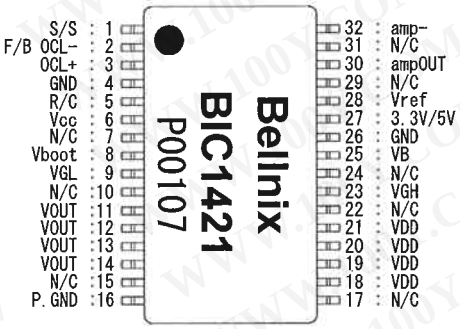
<External dimensions>



Terminal
base: Cu
plating: Ni/ Pd/ Au

Case
Black epoxy resin (UL94 V-0)

<Terminal functions>



Terminal No.	Symbol	Function
1	S/S	Soft-start capacitor terminal
2	F/B OCL-	Over-current－Detection terminal, feedback terminal
3	OCL+	Over-current detection terminal (+)
4,26	GND	Ground terminal
5	R/C	Remote ON/OFF control terminal
6	Vcc	Control circuit power supply terminal
8	Vboot	Main switch MOSFET control circuit power supply terminal
9	VGL	Low side MOSFET gate terminal for synchronous rectification
11-14	VOUT	Power supply output terminal
16	P.GND	Output circuit ground terminal
18-21	VDD	Main switch MOSFET power supply terminal
23	VGH	Main switch high side MOSFET gate terminal
25	VB	Output boot strap terminal. Used for connecting condensers across VB and VOUT terminals to boot strap IC internal main switch MOSFET control circuit.
27	3.3V/5V	Terminal for switching the output voltage
28	Vref	Internal reference voltage output terminal
30	ampOUT	Internal error amplifier output terminal
32	amp-	Internal error amplifier reversing input terminal
7,10,15,17 22,24,29,31	N/C	No connection terminal (N/C terminal)

<Peripheral functions>

1. Internal reference voltage (Vref)

IC internal circuitry reference voltage is provided by the temperature compensation reference voltage (5.0V). This reference voltage (Vref) provides a maximum external output current measured at the terminal of 1mA.

2. Oscillation circuit (OSC)

The oscillation circuit is built into the device. No external oscillation capacitor nor resistor is required. The oscillation frequency (250KHz) is set internally and has a sawtooth wave pattern. The sawtooth wave pattern cannot be outputted externally.

3. Error amplifier (Error amp)

The error amplifier senses the DC to DC converter voltage and provides a PWM control signal output. Loop gain between the error amplifier ampOUT terminal and the negative amp terminal is determined by the connections between the feedback resistor and the capacitor. This provides stable loop compensation throughout the system.

4. Over-current sensor (OCL)

The OCL is a pulse-by-pulse overcurrent sensor. The voltage drop across the external current sensing resistor is measured between the negative and positive terminals of the OCL. If the voltage drop exceeds 0.19V, the main switch (MOSFET) opens.

5. Switchable Output Voltage (3.3V/5.0V)

It is a terminal for switching the output voltage. Set the output voltage using this terminal.

Desired output 5.0V: Connect this terminal (27pin) to 26pin at "L" level.

Desired output 3.3V: Connect this terminal (27pin) to 28pin at "H" level.

6. Remote ON/OFF (R/C)

It is a remote terminal for output voltage ON/OFF control.

Output On: 0-0.5V (Ground this terminal to GND)

Output Off: 2.5-5.3V (This terminal is open)

7. Soft-start (S/S)

It is a capacitor connection terminal for soft-start.

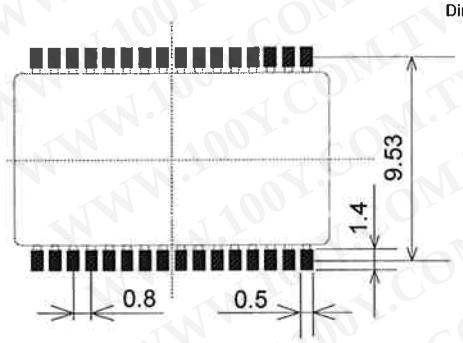
The ON range of main MOSFET at start-up will gradually enlarge by connecting a capacitor which is for soft-start to this terminal.

Connect a capacitor of approximately 0.1μF to this terminal..

<Mounting>

1. Soldering pattern reference (Reflow-type)

Dimensions: mm



2. Mounting cautions

Vibration and other mechanical disturbances can exert stress on the internal parts of the device. Carefully examine your equipment and place the device where vibration and other shock is minimal.

3. Soldering Conditions

The infrared reflow method is recommended. If the soldering time is too long or the soldering temperature is too high, it may damage the function of this IC, so be sure to use within the specified conditions.

1) Infrared reflow method

Temperature profile in the reflow method is as shown in the figure at the right.

2) Wave soldering conditions

- Pre-heating conditions

Center of the case temp.: 80-140°C

Pre-heating time: 30-60sec

- Heating conditions

Soldering temp.: 265±5°C

Heating time: 10±1sec

- Heating frequency: one time
- Notes

Solder bridge will be effected by the land, so give consideration when designing the printed board.

3) Storage conditions

After the dampproof package is opened, in an environment of temp. 30°C and relative temp. 70% or below: within 168Hrs.

4) Baking conditions

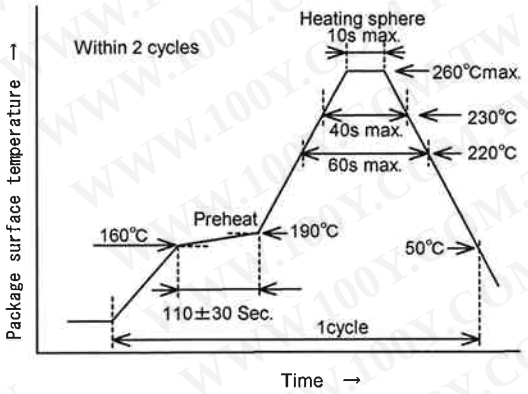
One time within 24Hrs. at 125°C

5) Soldering Iron

When using a soldering iron, execute under the following conditions.

- Soldering iron tip temp.: 380±10°C
- Heating time: 3±1sec
- Heating frequency: one time

Infrared and air reflow soldering conditions



4. Cleaning cautions

Carefully remove all flux. Allow time for the soldered areas to completely dry before using the device.

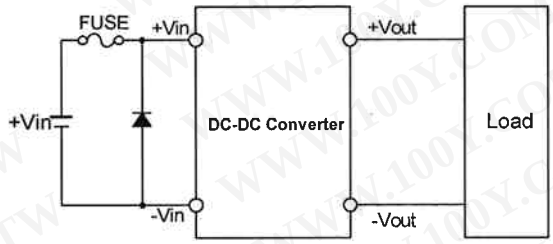
5. Resinous Coating

When remolding after mounting the device to the board, if the curing stress of the resinous is strong, it may give stress to the component. So be careful of choosing the resinous and calcify time.

<Usage>

1. To prevent reverse input voltage protection

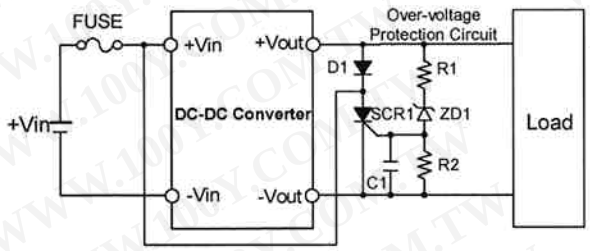
The BIC1421 device has an output current drop function. In the event of power IC device malfunction resulting in excessive input current flow, smoke and flame may be emitted from the equipment.
To prevent this, install fuse or protective circuitry to the power IC device input line. Install the fuse or protective circuitry to the positive side of the input line. Be sure that the fuse or protective circuitry is not too large to effectively protect the circuitry (the input line must be capable of carrying enough current to blow the fuse).



2. Over-voltage protection

The BIC1421 power IC device does not have an over-voltage (voltage surge) protection function. If a malfunction occurs in the device internal circuitry, there may be a voltage surge. Output will reflect this surge and damage to equipment may result. Smoke and flame may be emitted from the equipment. To prevent this, be sure to install voltage surge sensing and protection circuitry.
There are a number of ways to protect against voltage surge.
Figure shows a typical voltage surge protection set-up. The voltage surge sensing and protection circuit should be installed as close as possible to the load (away from the output smoothing capacitor).

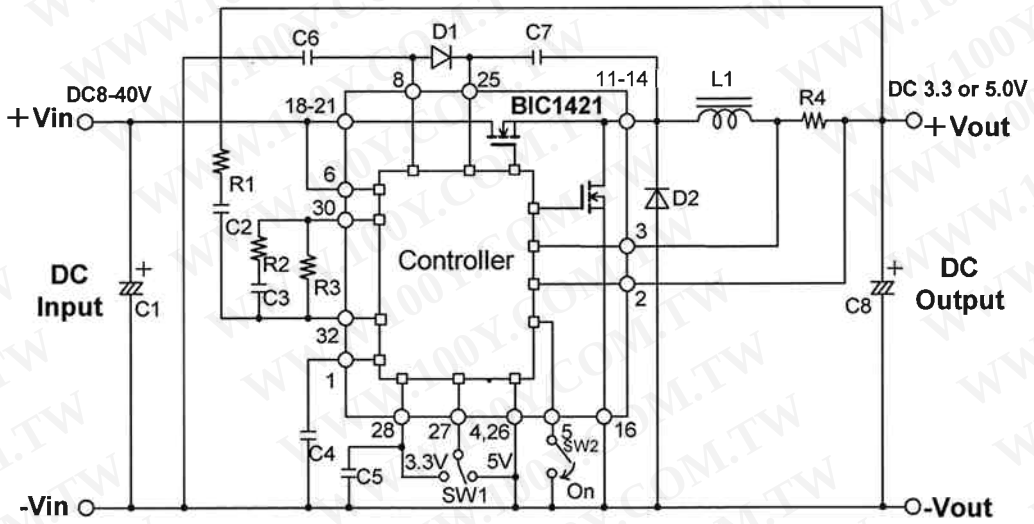
Reference part example



<Standard connections>

BIC1421 is a power IC developed for synchronous rectification type chopper method. This IC has built the major components of the controller IC part, high-side and low-side MOSFET for commutating etc. into one package. Accessories such as external choke and capacitor are required for this device.

- 27pin is for switching the output voltage
  Output voltage 3.3V: 27pin and 28pin is short
  Output voltage 5.0V: 27pin and 26pin is short
- 9 and 23pins are the test terminals and must be left open.
- 7, 10, 15, 17, 22, 24, 29 and 31pins are N/C terminals (internally unconnected).
- Be sure to prepare and connect the external parts shown in the diagram below.
- The use of a low ESR product is recommended for output smooth capacitor.



<Reference parts>

Parts No.	Component	Output Voltage 3.3V/ 5.0V Output current example		Type/ Manufacturer
		1.2A	3.0A	
IC1	MCM−IC	BIC1421	BIC1421	Bellnix
L 1	Choke	22μH, 1.5A CDRH type	22μH, 3.6A CDRH type	Sumida Electric
D 1	Diode	1SS300	1SS300	Toshiba
D 2	Shottky diode	D1FS6	D1FS6	Shindengen
R 1	Resistance	0.1W, 5.6K	0.1W, 5.6K	Hokuriku Electric Industry
R 2	Resistance	0.1W、27K	0.1W, 27K	Hokuriku Electric Industry
R 3	Resistance	0.1W、300K	0.1W, 300K	Hokuriku Electric Industry
R 4	Resistance	0.75W, 0.1Ω SR73K type	1W, 0.039Ω NPR type	KOA
C 1	Electrolyte capacitor	50V、220μF	50V, 220μF （2pcs parallel	KZE type Nippon Chemi-con
C 2	Ceramic capacitor	25V、0.047μF	25V, 0.047μF	GRM39 type or GRM40 type Murata or C1608 type or C2012 type TDK
C 3	Ceramic capacitor	50V、2200PF	50V, 2200PF	
C 4	Ceramic capacitor	25V、0.047μF	25V, 0.047μF	
C 5	Electrolyte capacitor	16V、0.1μF	16V, 0.1μF	
C 6	Ceramic capacitor	50V、1000PF	50V, 1000PF	
C 7	Ceramic capacitor	50V、0.01μF	50V, 0.01μF	
C 8	Electrolyte capacitor	10V、680μF	10V, 680μF （2pcs parallel	KZE type Nippon Chemi-con

Due to conditions, the fixed numbers may change.

<Electrical Characteristics> (Typical ex.)

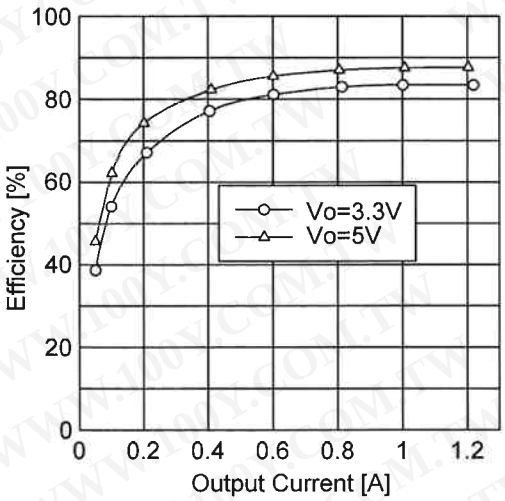
Below is a reference data measured with a circuit composed with additional components and reference components by fixed numbers based upon standard connection circuit diagram.

(Ta=25℃)

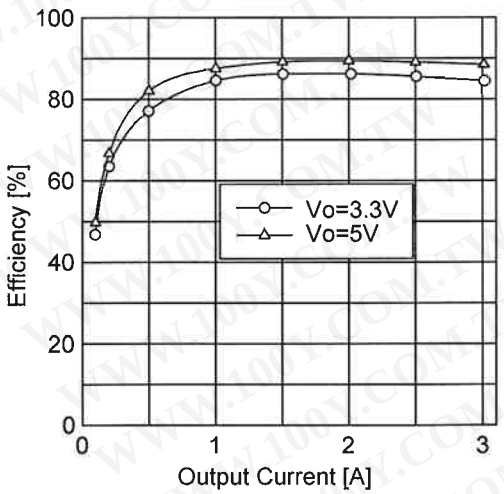
Item	Component	Output Current Ex.				Conditions
		1.2A		3.0A		
Rating Output Voltage	V	3.3	5.0	3.3	5.0	
Rating Output Current	A	1.2		3.0		
Rating Input Voltage	V	24				
Input Voltage Range	V	8-40				
Output current	A	0-1.2		0-3.0		
Output Voltage Setting Accurac	%	0.97	0.98	0.88	1.96	
Input Current (At no load)	mA	11	12	16	21	
Input Current (At rating load)	A	0.197	0.280	0.503	0.714	
Efficiency (At rating load)	%	83.51	87.84	83.71	85.9	
Line Regulation	%	1.91	2.38	1.79	2.15	For the line regulation 8V-40V.
Load Regulation	%	0.14	0.36	0.52	0.66	For the load regulation 0-100%
Ripple & Noise	mVp-p	13/39	15/39	32/80	36/80	
Over-current protection	A	1.64	1.54	3.7	3.5	
Standby Current	mA	0.53	0.53	0.53	0.53	At remote OFF
Oscillation frequency Typ.	KHz	250KHz fixed frequency				

* The above input and output specification is provided with rating value, unless otherwise specified.

Efficiency—Output Current Characteristics
(Input voltage=24V)



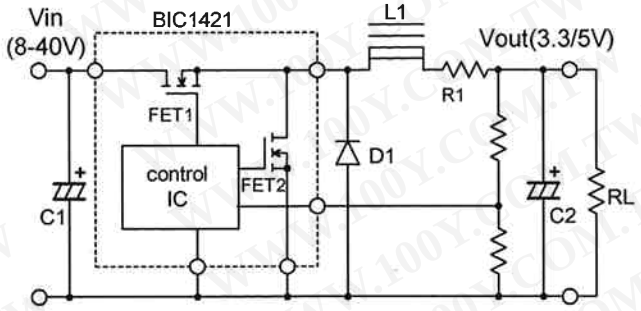
Efficiency—Output Current
Characteristics
(Input voltage=24V)



<Basic operation explanation>

This Power IC BIC1421 adopts the synchronous rectification method. With this method, the DC-DC converter has high efficiency and can supply large current.

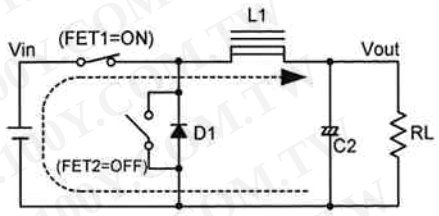
1. Basic circuit



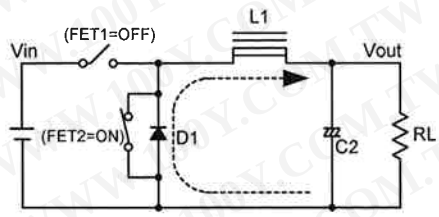
FET1 : Main switch MOSFET
FET2 : Bottom MOSFET
D1 : Free Wheeling Diode
R1 : Current detection resistance
C1 : Input Capacitor
C2 : Output Capacitor

In general step-down chopper converters, the commutation circuit part is composed of diode D1 alone. In synchronous rectification type, FET2 is connected parallel to this commutation diode and the efficiency is improved. Moreover, it was general to adopt a P-channel when using a FET as a main switch, however with this Power IC BIC1421 a boost circuit is built-in and the main switching is done at the N-channel of MOSFET, thereby the efficiency can also be improved.

2. Flow of the main current



(a) At ton Current

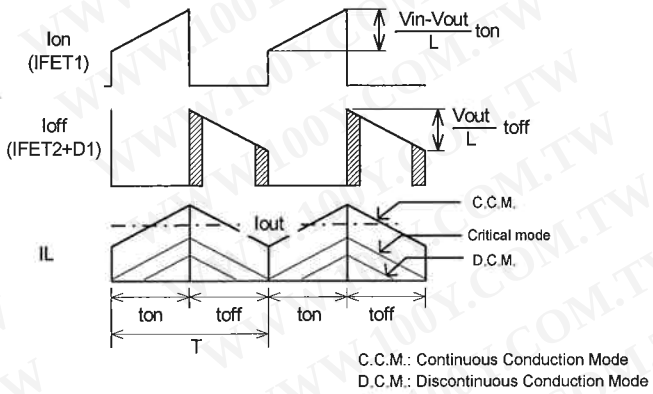


(b) At toff current

At ton: Passes FET1 and current flows into L1.
At toff: Excitation current that has been saved at L1 go though FET2 (D1) and commutates.

3. Main current wave

Main Current Wave is shown in the figure below.



C.C.M.: Continuous Conduction Mode
D.C.M.: Discontinuous Conduction Mode

At toff, the excitation current of the choke goes through D1, FET2 and commutates. But at the oblique parts it goes through D1 and the middle part goes through FET2.

There are three current modes that flow into the choke. The superposed mode of direct current at rating load etc. is called C.C.M. The mode when current that flows into the choke is intermittent at light load is called D.C.M. The boundary between the C.C.M. and D.C.M. is called the critical mode. At C.C.M., the voltage applied to the choke during ton period becomes Vin-Vo, therefore the current inclination ⊿IL will be

$$\Delta IL(ton) = \frac{Vin - Vo}{L} \times ton$$

When the FET1 goes off next, the ccurrent that has been flowing into the inductance will try to keep flowing into the same go through D1, FET2 and start commutation. For the commutating current, the same current value of the value right before FET1 went off will flow, and the same voltage as the output voltage will be added to the both ends of L1. Therefore the current inclination ⊿IL when off will be

$$\Delta IL\ (toff) = \frac{Vo}{L} \times toff$$

And for C.C.M. the current inclination ⊿IL is the same, so it will be

$$Vo = \frac{ton}{ton + toff} \times Vin = \frac{ton}{T} \times Vin$$

To calculate the smooth choke inductance, design it so that the critical operation can be 15-20% of the rating current. Therefore, the inductance can be calculated with the equation below.

$$L = \frac{Vin - Vo}{\Delta IL} \times ton = \frac{Vin - Vo}{(0.15\ to\ 0.2) \times Io \times 2} \times \frac{Vo}{Vin \times f}$$

* The equation on page 9 of the set-up standards, has put in consideration of diode Vf.

<Basic device set-up standards>

In the following order, the addition parts are designed.

1. Over-current detecting resistor (R1) selection
2. Inductance (L1) selection
3. Output capacitor (C2) selection
4. Input capacitor (C1) selection

1. Over-current detecting resistor (R1) Selection method

The output current is detected by the drop voltage of resistor R1.
The over-current protection circuit of pulse by pulse method operates when the voltage generated at the resistance is 0.19V±15%.

$$R1 = \frac{Vth}{Iocp} [ohm]$$

Vth: Over-current detecting voltage (0.19V±15%)
Iocp: Over-current operating point

At the over-current operating point, the maximum output current will be set at 110-120%. At the over-current operating point, switching noise and other factors may cause some variation in the calculated value. Check your own equipment and calculate the value accordingly.

2. Inductance (L1) selection

Inductance is determined so that ⊿IL is 30% of the rating output current at the maximum input voltage.

$$L1 = \frac{(Vin(max) - Vo) \times (Vo + Vf)}{\Delta IL \times (Vin(max) + Vf) \times f} [H]$$

Vin (max): Maximum input voltage
Vo: Output voltage
Vf: Forward voltage of the commutation diode (approx. 0.5V)
⊿IL: 15-20% of output current (Io×0.15 to 0.2)
f: Oscillation frequency (250kHz)

Regarding choke coil selection, be careful of direct superposition characteristics, not to saturate the choke coil even in the over-current area.

3. Output capacitor (C2) selection

If an electrolytic capacitor is used, output ripple is determined by⊿IL and capacitor impedance. Use the equation below to calculate the value. Select a device providing an impedance (Zc) lower than the calculated value.

$$Zc = \frac{Vrip}{\Delta IL}$$

Vrip: Output ripple voltage (Ex. 30mVp-p)
⊿IL: 15-20% of output current

4. Input capacitor (C1) selection

A large ripple current flows through the input capacitor. Use the equation below to calculate the value. Select a device providing a higher ripple current capacity (Irip) than the calculate value.

$$D = \frac{Vo + Vf}{Vi(min) + Vf}$$

$$Irip = \sqrt{D(1 - D)} \times Io$$

D: Duty (Ton/T)
Vo: Output voltage
Vin (min): Minimum input voltage
Vf: Forward voltage of the commutation diode (approx. 0.5V)

5. Thermal management

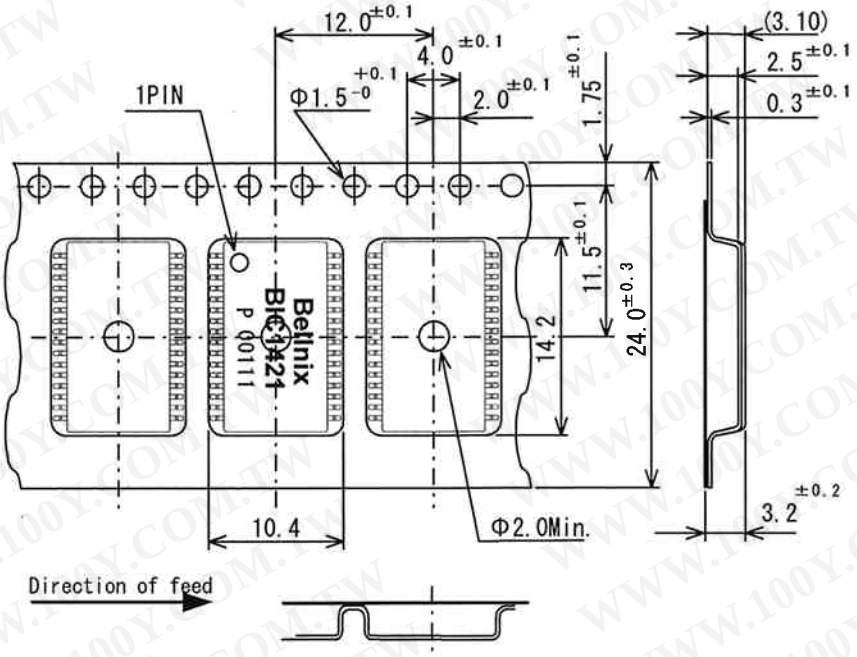
Temperature increase varies with input voltage, output voltage and output current. Case surface temperatures should no exceed 105°C. Set up your equipment accordingly.

<Packaging>

Dimensions: mm

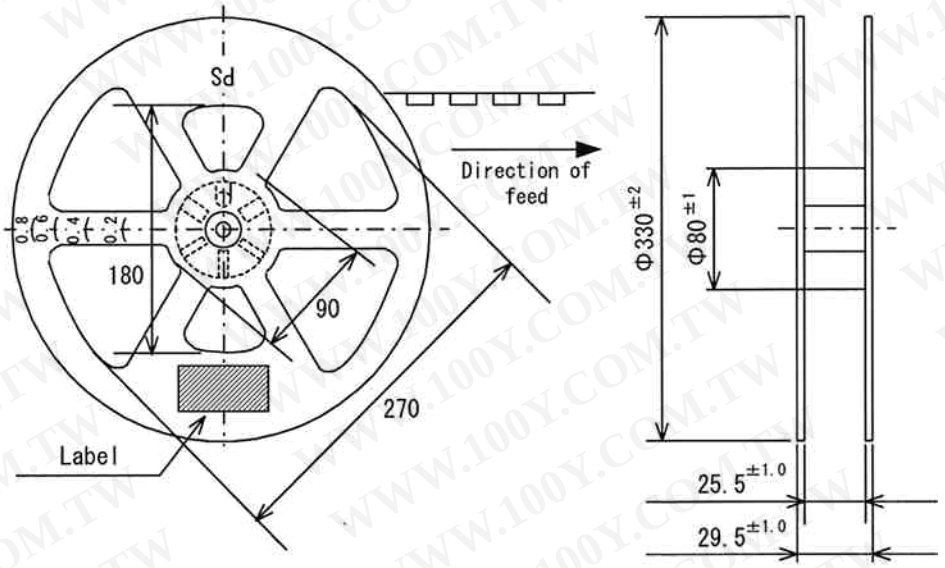
1. Tape & Reel

• Dimensions comply with JIS , C-0806-3

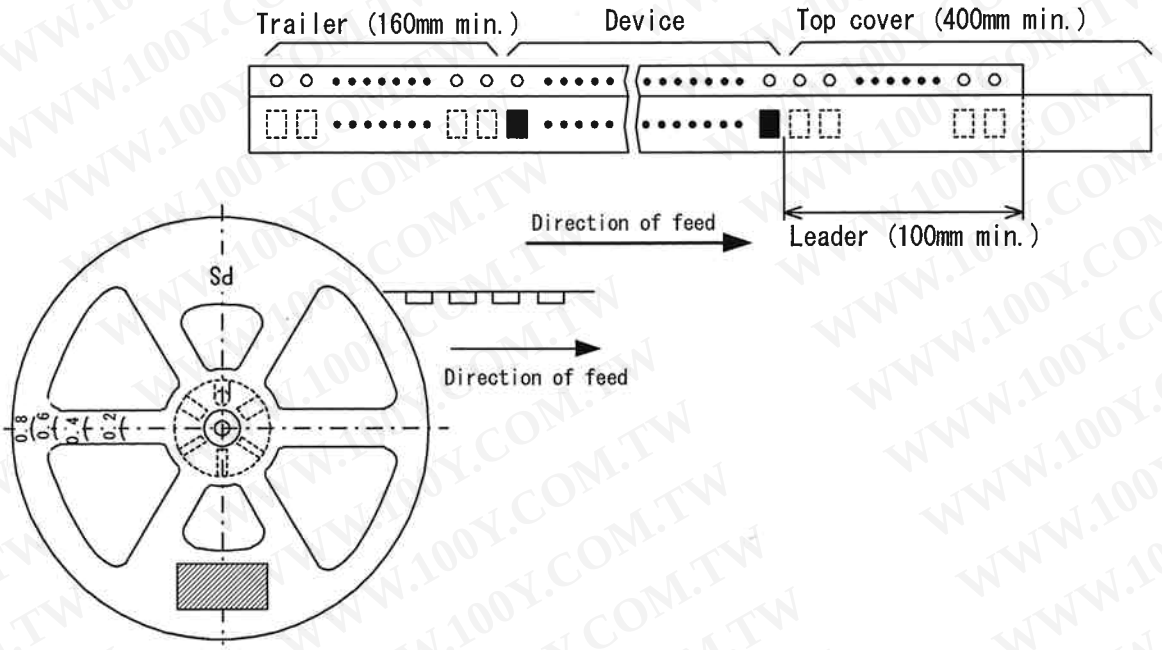


2. Reel

• Material : Polystyrene+Carbon



3. Leader and Trailer



<Precautions>

- This product is for being used in general electric equipments (business equipments, telecommunication equipments and measurement equipments). May not be used in medical equipments, nuclear equipments and trains which would affect lives or properties directly by the failure of this product.
- Do not remodel, process or use in a non-standard, it may cause serious accidents. We can not take responsibility for those products used in a wrong way or in a non-standard.
- When there is a problem, an excessive voltage may occur to the output and cause voltage decrease. Built-in a protection circuit (over-voltage protection, over-current protection etc.) assuming to have problems of malfunction and damage of equipments.
- Always keep the standards (input voltage, operating temperature and so on), without fail and be sure to insert a protection element to the input line. Also, always confirm each polarity (input and output) that there is no miss wiring before energizing. <<Wrong way of using will cause smoke fire.>>
- This product does not have a built-in over-voltage protection. When over-voltage occurs due to the abnormality in the module, there is a mode that input voltage comes out at it is, and may cause smoke and ignition. To prevent this, be sure to add over-voltage protection.
  <<When over-voltage occurs, the remote ON/ OFF pin of this IC do not function .>>
- The contents specified herein are accurate and reliable, however we shall not take any responsibilities for any damages and loss or infringement of patent and any other rights, as a result of using these materials.
- This material does not guarantee the execution of patent or other rights of third party or approve the right of execution hereof.
- Reprinting and copying these materials are not allowed partially or totally without our prior written approval.

Export regulations for stragety goods

- Classified into integrated circuits, in the export regulations 1-7 section of the attached table, and the ordiance of the Ministry of Economy, Trade and Industry clause 6.
- This product is a subject for KNOW regulation.

Bellnix®

Bellnix. Co., Ltd.
5-7-8 Negishi Saitama-shi, Saitama, JAPAN 336-0024
TEL: 048-864-7733 FAX: 048-861-6402
E-mail: info@bellnix.co.jp
URL: http://www.bellnix.co.jp/

*All specification are subjected to change without notice.

Printed in Japan BD20050412－050704

Bellnix POWER SUPPLY
Dream and Creation