

AC/DC Drivers

AC/DC controller IC for LED lighting Included 650V MOSFET

BM521Q25F

General Description

BM521Q25F is an AC/DC converter for LED lighting, which has a built-in MOSFET with 650V withstand voltage. This IC can be applied to quasi-resonant typed High-side LED driver application, and the high current precision and Low EMI noise can be achieved. Moreover, owing to the built-in PFC (Power Factor Correction) converter, the harmonics is improved.

Owing to the start-up circuit with 650V withstand voltage, the low power consumption is achieved. And owing to the external current setting resistance, a power supply design with a high degree of freedom can be achieved.

Owing to the built-in start-up circuit and MOSFET with 650V withstand voltage, a compact application can be designed easily, and the low-cost can be achieved with the small BOM size.

Features

- Quasi-resonant Switching Mode + PFC Circuit
- Non-isolated Application
- Built-in 650V Start-up Circuit
- Built-in 650V Switching MOSFET
- Maximum Frequency 300kHz
- VCC Pin: Under Voltage Protection
- VCC Pin: Over Voltage Protection (Latch)
- SOURCE Pin: Leading-Edge-Blanking Function
- SOURCE Pin: OPEN Protection Function
- LED Over Current Detection Function

Package
SOP8

W(Typ) x D(Typ) x H(Max)
5.00mm x 6.20mm x 1.71mm



Key Specifications

- Operating Power Supply Voltage Range:
VCC: 8.9V to 25.0V
DRAIN: to 650V
- Operating Current: Normal Operation: 400μA (Typ)
- Operating Temperature Range: - 40°C to +105°C
- MOSFET ON Resistance: 4.0Ω (Typ)

Application

LED Bulb, Down-light etc.
Electrical Machineries for LED Lighting

Typical Application Circuit

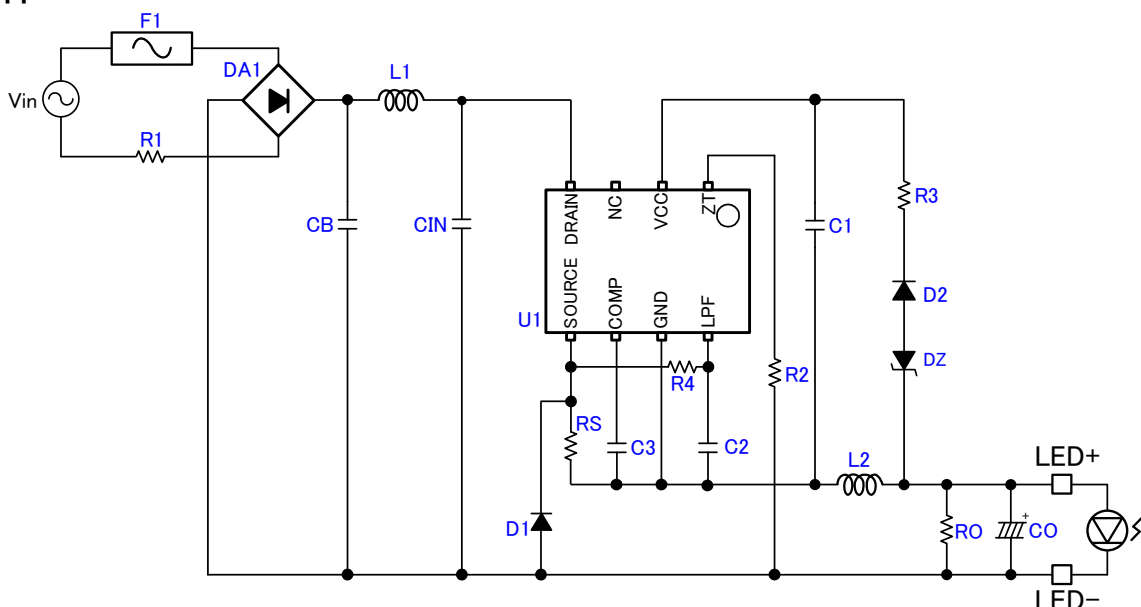


Figure 1. Application Circuit

Absolute Maximum Ratings (Ta=25°C)

| Item | Symbol | Rating | Unit | Condition |
|------------------------------|-------------------|-------------|------|-------------------------------------|
| Input Voltage Range 1 | V _{max1} | -0.3 to 30 | V | VCC |
| Input Voltage Range 2 | V _{max2} | -0.3 to 6.5 | V | SOURCE, COMP, LPF, ZT |
| Input Voltage Range 3 | V _{max3} | 650 | V | DRAIN |
| Drain Current Pulse | I _{DP} | 2.60 | A | P _W =10μs, Duty Cycle=1% |
| Operating Temperature Range | T _{opr} | -40 to +105 | °C | |
| Maximum Junction Temperature | T _{jmax} | 150 | °C | |
| Storage Temperature Range | T _{stg} | -55 to +150 | °C | |

Caution: Operating the IC over the absolute maximum ratings may damage the IC. The damage can either be a short circuit between pins or an open circuit between pins and the internal circuitry. Therefore, it is important to consider circuit protection measures, such as adding a fuse, in case the IC is operated over the absolute maximum ratings.

Thermal Resistance (Note 1)

| Parameter | Symbol | Thermal Resistance (Typ) | | Unit |
|--|-----------------|--------------------------|--------------------------|------|
| | | 1s ^(Note 3) | 2s2p ^(Note 4) | |
| SOP8 | | | | |
| Junction to Ambient | θ _{JA} | 197.4 | 109.8 | °C/W |
| Junction to Top Characterization Parameter ^(Note 2) | Ψ _{JT} | 21 | 19 | °C/W |

(Note 1) Based on JESD51-2A (Still-Air)

(Note 2) The thermal characterization parameter to report the difference between junction temperature and the temperature at the top center of the outside surface of the component package.

(Note 3) Using a PCB board based on JESD51-3.

(Note 4) Using a PCB board based on JESD51-7.

| Layer Number of Measurement Board | Material | Board Size |
|-----------------------------------|-----------|---------------------------|
| Single | FR-4 | 114.3mm x 76.2mm x 1.57mm |
| Top | | |
| Copper Pattern | Thickness | |
| Footprints and Traces | 70μm | |

| Layer Number of Measurement Board | Material | Board Size |
|-----------------------------------|----------|--------------------------|
| 4 Layers | FR-4 | 114.3mm x 76.2mm x 1.6mm |

| Top | | 2 Internal Layers | | Bottom | |
|-----------------------|-----------|-------------------|-----------|-----------------|-----------|
| Copper Pattern | Thickness | Copper Pattern | Thickness | Copper Pattern | Thickness |
| Footprints and Traces | 70μm | 74.2mm x 74.2mm | 35μm | 74.2mm x 74.2mm | 70μm |

Recommended Operating Conditions (Ta=25°C)

| Item | Symbol | Range | Unit | Condition |
|-----------------------|--------------------|-------------|------|---------------|
| Input Voltage Range 1 | VCC | 8.9 to 25.0 | V | VCC Voltage |
| Input Voltage Range 2 | V _{DRAIN} | to 650 | V | DRAIN Voltage |

Electrical Characteristics MOSFET (Unless otherwise specified V_{CC}=15V Ta=25°C)

| Item | Symbol | Specification | | | Unit | Condition |
|--------------------------------|----------------------|---------------|-----|-----|------|--|
| | | Min | Typ | Max | | |
| Drain-Source Breakdown Voltage | V _{(BR)DDS} | 650 | - | - | V | I _D =1mA / V _{GS} =0V |
| Drain Leakage Current | I _{DDS} | - | - | 100 | μA | V _{DS} =650V / V _{GS} =0V |
| ON Resistance | R _{DS(ON)} | - | 4.0 | 5.5 | Ω | I _D =0.25A / V _{GS} =10V |

Electrical Characteristics IC (Unless otherwise specified V_{CC}=15V Ta=25°C)

| Item | Symbol | Specification | | | Unit | Condition |
|---------------------------------------|---------------------|---------------|-------------------------|-------|------|--|
| | | Min | Typ | Max | | |
| [Circuit Current] | | | | | | |
| Circuit Current (ON) | I _{ON} | - | 400 | 800 | μA | ZT=0V(PULSE Operating) |
| Circuit Current (OFF) | I _{OFF} | - | 300 | 600 | μA | ZT=1V(PULSE OFF) |
| [VH Pin Start Up Circuit] | | | | | | |
| VH Starting Current 1 | I _{START1} | 0.20 | 0.55 | 0.90 | mA | VCC= 0V |
| VH Starting Current 2 | I _{START2} | 1 | 3 | 6 | mA | VCC=10V |
| VH OFF Current | I _{START3} | - | 10 | 20 | μA | VCC UVLO Released VH Pin Sink Current |
| VH Starting Current Switching Voltage | V _{SC} | 0.4 | 0.8 | 1.6 | V | VCC Pin |
| [VCC Pin Protection] | | | | | | |
| VCC UVLO Voltage 1 | V _{UVLO1} | 12.5 | 13.5 | 14.5 | V | VCC Rising Up |
| VCC UVLO Voltage 2 | V _{UVLO2} | 7.5 | 8.2 | 8.9 | V | VCC Falling Down |
| VCC UVLO Hysteresis | V _{UVLO3} | - | 5.3 | - | V | V _{UVLO3} = V _{UVLO1} - V _{UVLO2} |
| VCC OVP Trigger Voltage | V _{OVP1} | 25.0 | 27.5 | 30.0 | V | VCC Rising Up |
| VCC OVP Release Voltage | V _{OVP2} | 21.0 | 23.5 | 26.0 | V | VCC Falling Down |
| Latch Released VCC Voltage | V _{LATCH} | - | V _{UVLO2} -0.5 | - | V | VCC Falling Down |
| VCC Recharge Start Voltage | V _{CHG1} | 7.7 | 8.7 | 9.7 | V | VCC Falling Down |
| VCC Recharge End Voltage | V _{CHG2} | 12 | 13 | 14 | V | VCC Rising Up |
| Latch Mask Time | T _{LATCH} | 75 | 150 | 300 | μs | |
| [DC/DC Converter Block (Turn-on)] | | | | | | |
| ZT Comparator Voltage 1 | V _{ZT1} | 30 | 110 | 190 | mV | ZT Falling Down |
| ZT Comparator Voltage 2 | V _{ZT2} | 100 | 200 | 300 | mV | ZT Rising Up |
| ZT Comparator Hysteresis | V _{ZTHYS} | 40 | 90 | 140 | mV | V _{ZTHYS} = V _{ZT2} - V _{ZT1} |
| ZT Trigger Timeout | T _{ZTOUT} | 9 | 18 | 36 | μs | |
| [DC/DC Converter Block (Turn-off)] | | | | | | |
| Current Trigger Voltage | V _{CS} | 2.60 | 2.95 | 3.30 | V | |
| Maximum Frequency | F _{SW} | 255 | 300 | 345 | kHz | |
| Leading Edge Blank Time | T _{LEB} | 0.1 | 0.2 | 0.4 | μs | |
| Error Amplifier Reference Voltage | V _{REF} | 0.582 | 0.600 | 0.618 | V | |

Pin Configuration

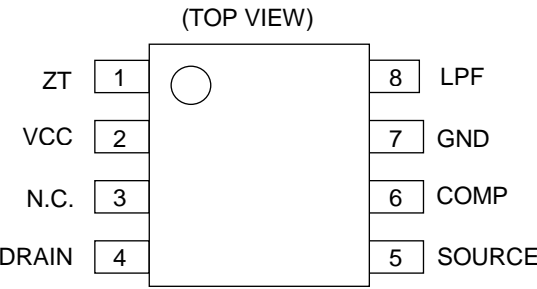


Figure 2. Pin Configuration

Pin Descriptions

Table 1. PIN Functions

| Pin No. | Pin Name | Function |
|---------|----------|--|
| 1 | ZT | Zero current detecting pin |
| 2 | VCC | Power supply pin |
| 3 | N.C. | Non Connection |
| 4 | DRAIN | Internal MOSFET DRAIN pin |
| 5 | SOURCE | Internal MOSFET SOURCE pin Inductor current sensing pin |
| 6 | COMP | Error amplifier output pin |
| 7 | GND | GND pin |
| 8 | LPF | Error amplifier input pin |

I/O Equivalence Circuits

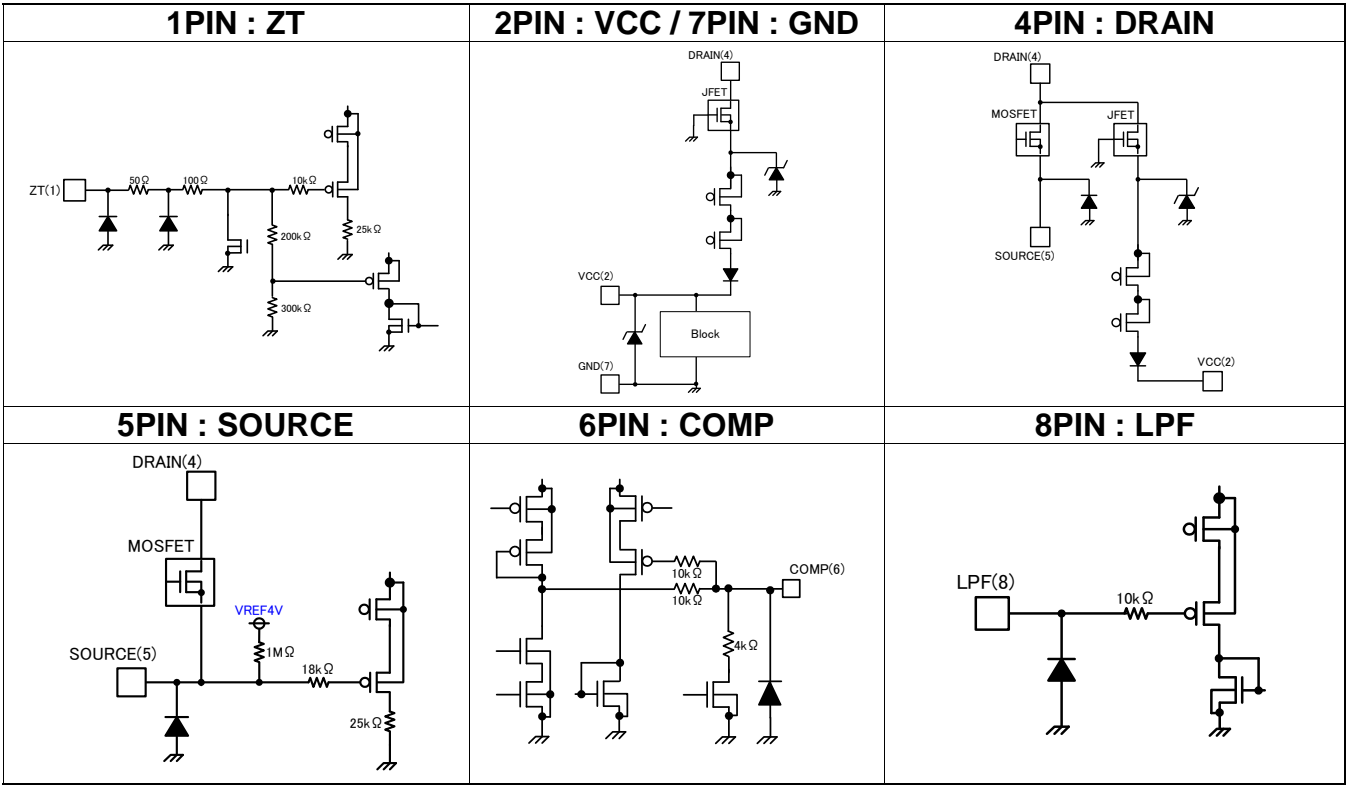


Figure 3. I/O Equivalent Circuits

Block Diagram

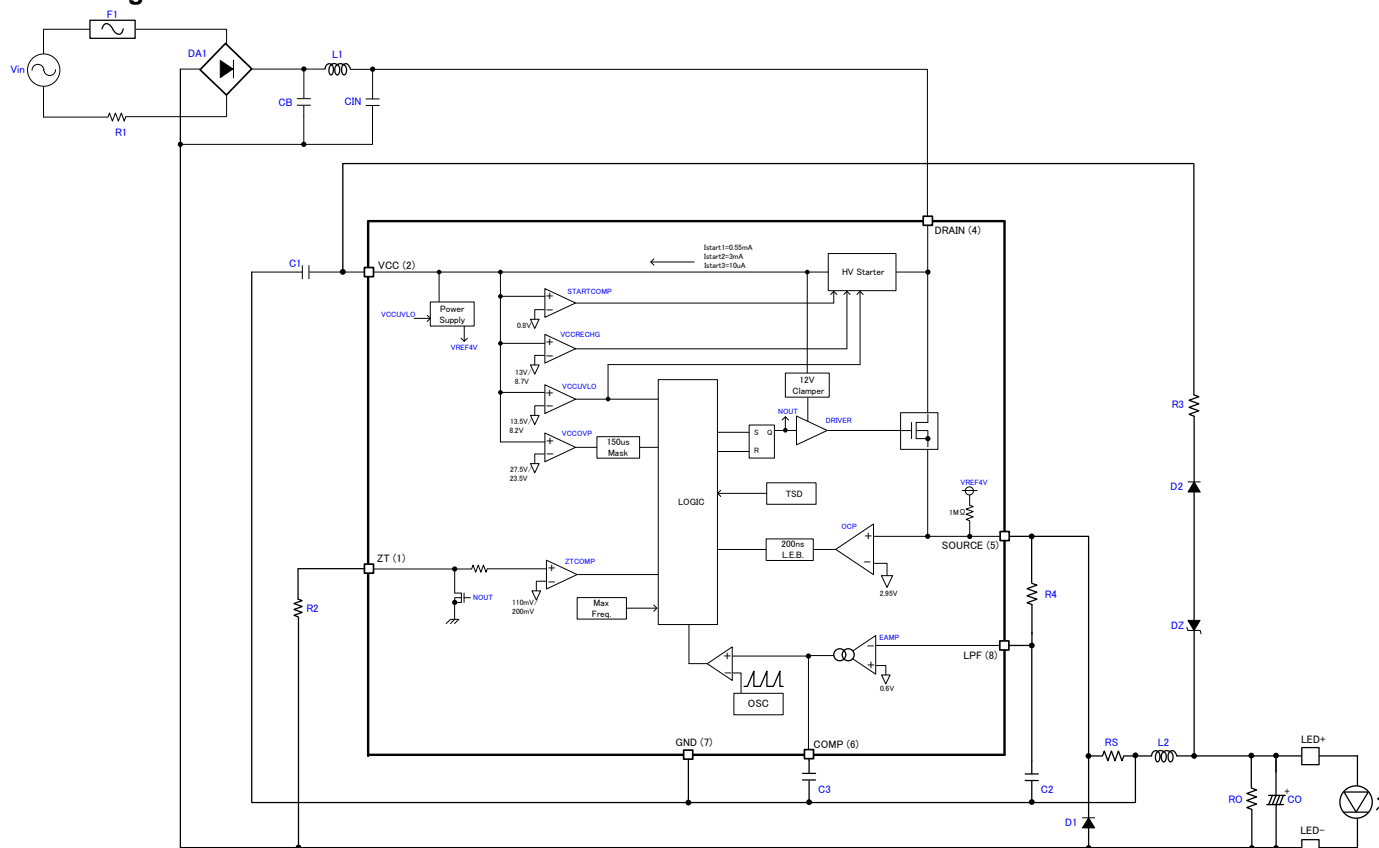


Figure 4. Block Diagram

Description of Blocks

(1) Start-up Circuit Block (VCC:2pin, DRAIN : 4pin)

(1.1)Block Description

A start-up circuit with 650V withstand voltage is built in this IC. Owing to this, the low-power standby and high-speed start can be achieved. After the IC was booted up, the power consumption becomes only the idling current I_{START3} (Typ=10μA).

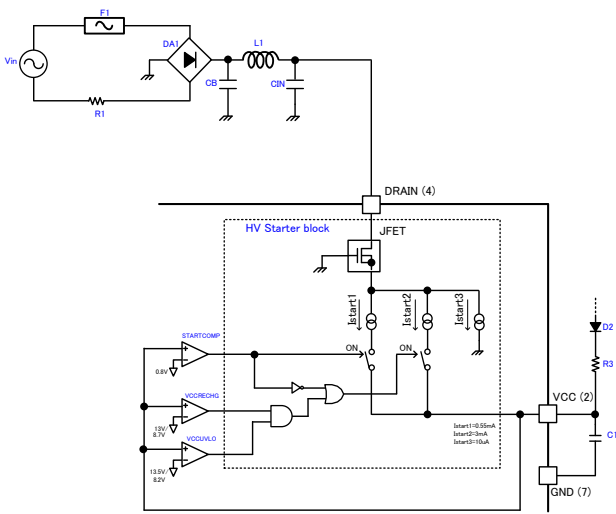


Figure 5. Start-up Circuit Block Diagram

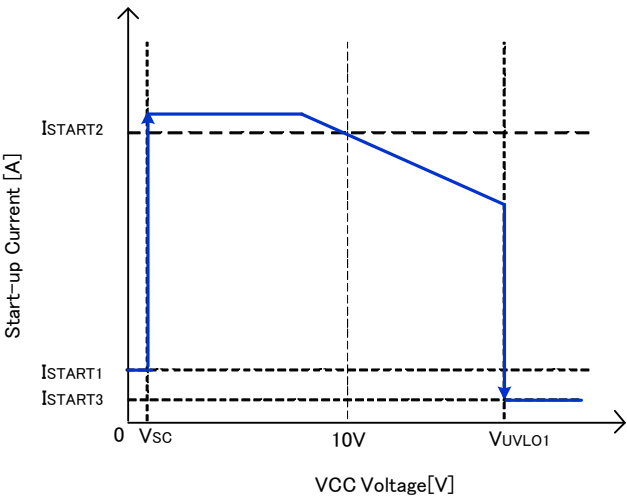


Figure 6. Start-up Current – VCC Voltage Curve

(1.2)Start Sequences

The time chart of the start sequences are showed in Figure 8.

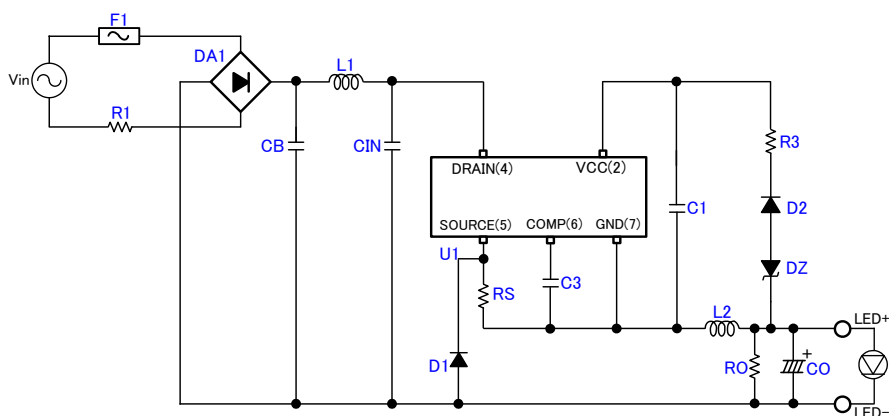


Figure 7. DC/DC Schematic

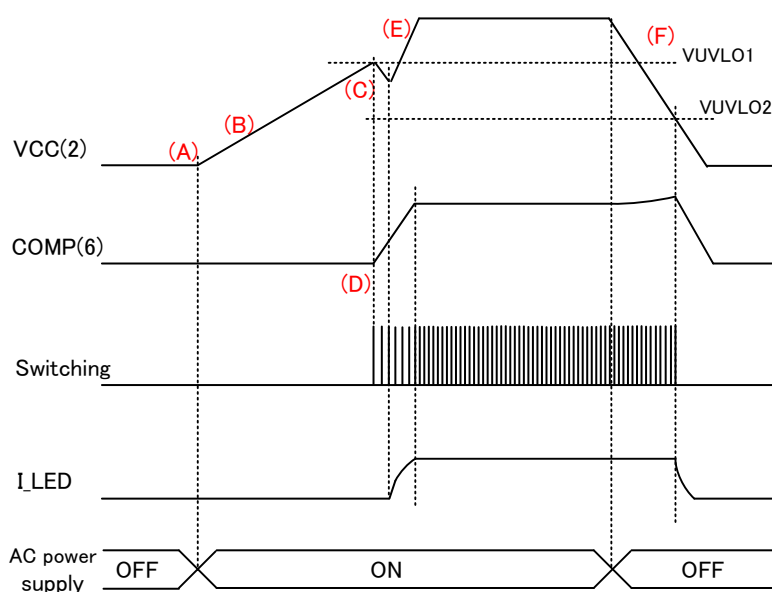


Figure 8. ON/OFF Sequences

ON/OFF Sequences

A: Input voltage is applied to DRAIN pin while the AC power supply turns to ON.

B: The capacitor connected to the VCC pin is charged by the start-up current from the DRAIN pin, and the VCC rises up.

C: The IC starts operating when $V_{CC} > V_{UVLO1}$ (Typ=13.5V).

D: By the increasing of the COMP pin voltage, the IC starts up with the soft start operation.

E: The current is supplied to VCC pin from LED+ and D2 by the switching operation.

※The power is supplied from V_{LED} , and the VCC voltage is determined by the V_{DZ} (the breakdown voltage of DZ).

$$V_{CC} = V_{LED} - V_{DZ} - V_{fD2}$$

(V_{LED} : the V_f of LED, V_{DZ} : the breakdown voltage of DZ, V_{fD2} : the V_f of D2)

F: When the power supply turns OFF, VCC voltage falls down due to the drop of the power supply.

The IC turns OFF when the V_{UVLO2} (Typ=8.2V) is triggered.

(1.3) VCC Pin Protection Function

The VCC under voltage protection function VCC UVLO (Under Voltage Lock Out), over voltage protection function VCC OVP (Over Voltage Protection), and a VCC recharge function which operates when a voltage drop occurs at VCC pin are built in this IC. The VCC UVLO and VCC OVP functions are used for preventing the destructions of the switching MOSFET which occurs when the VCC voltage is too high or too low.

Owing to the VCC charge function, the VCC pin is charged from high voltage lines by the start circuit when the VCC voltage drops.

VCC UVLO / VCC OVP Function

VCC UVLO and VCC OVP are auto recovery comparators which have voltage hysteresis.

VCC OVP has a built-in mask time T_{LATCH} (Typ=150 μ s).

When the VCC voltage is over V_{OVP1} (Typ=27.5V), and this state lasts T_{LATCH} , the detection is executed.

Owing to this function, the surge which occurs at VCC pin can be masked.

VCC Charge Function

When the VCC pin voltage is over V_{UVLO1} (Typ=13.5V), the IC starts up. In this case, if the VCC pin voltage drops below V_{CHG1} (Typ=8.7V), VCC charge function operates. At this time, the VCC pin is charged from the DRAIN pin through the start-up circuit. Owing to this operation, the failure of start-up can be prevented.

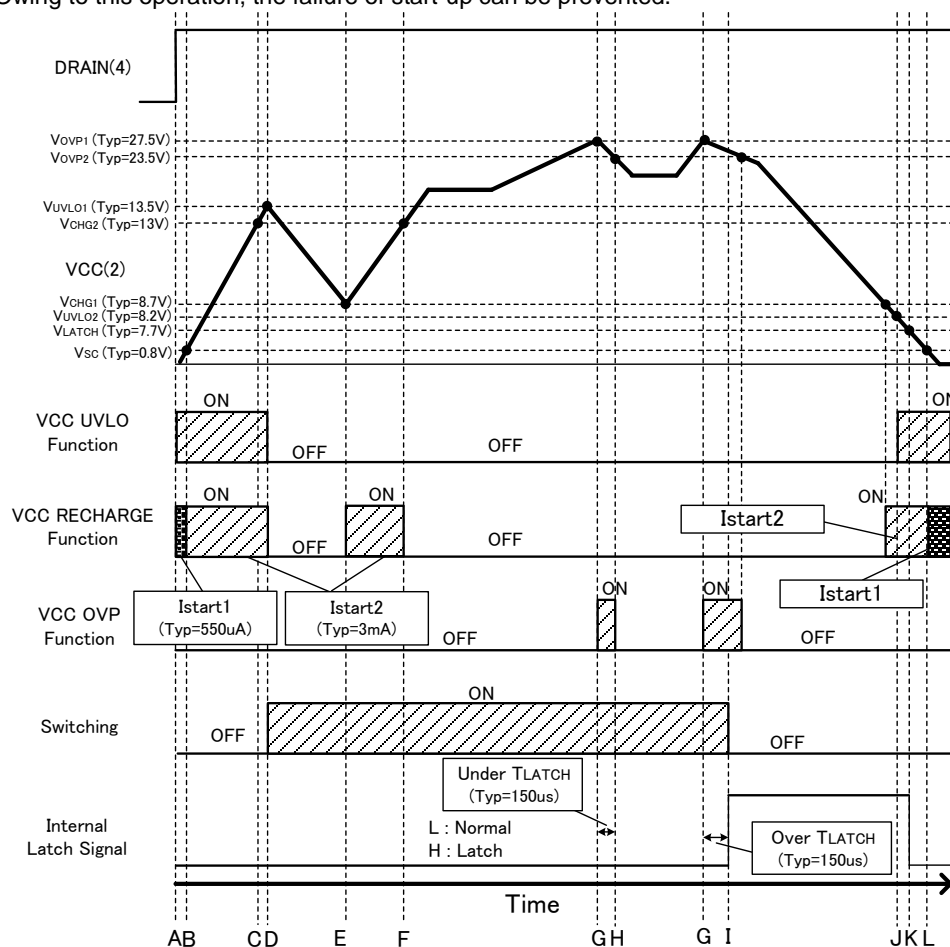


Figure 9. Timing Chart of VCC UVLO/ VCC OVP / VCC Charge Function

- A: DRAIN pin voltage is applied, VCC voltage rises by the charging current I_{start1} (Typ=550 μ A).
- B: VCC voltage > V_{SC} (Typ=0.8V), the charging current to VCC changes from I_{start1} to I_{start2} (Typ=3mA)
- C: VCC voltage > V_{CHG2} (Typ=13V), though VCC charge function reacts, due to VCC UVLO is detected, the charge continues.
- D: VCC voltage > V_{UVLO1} , the VCC UVLO is released, and DC/DC operation starts, the charge to VCC stops.
- E: VCC voltage < V_{CHG1} , the charge to VCC restarts.
- F: VCC voltage > V_{CHG2} , VCC recharge function stops..
- G: VCC voltage > V_{OVP1} , VCC OVP is detected.
- H: VCC voltage < V_{OVP2} (Typ=23.5V), if VCC voltage drops below V_{OVP2} in T_{LATCH} , VCC OVP is released, and the latch will not be activated.
- I: VCC voltage > V_{OVP2} , if this state is kept longer than T_{LATCH} , the switching stops by latch.
- J: VCC voltage < V_{UVLO2} (Typ=8.2V), VCC UVLO is detected.
- K: VCC voltage < V_{LATCH} (Typ=7.7V), the latch state is released.
- L: VCC voltage < V_{SC} , the charging current to VCC changes from I_{start2} to I_{start1} .

(2)Error Amplifier Block (SOURCE: 5pin, COMP: 6 pin, LPF: 8pin)**(2.1)Block Description**

An error amplifier is built in this IC, the Gate ON time of the built-in MOSFET is changed by controlling the output of the error amplifier.

The voltage which occurs on the current sensing resistor RS (SOURCE Pin Voltage) is inputted to the low pass filter circuit which is composed by R4,C2. The output of the low pass filter circuit (LPF Pin Voltage) is used as the input voltage of the error amplifier, and the summation of the current which flows through the inductor L2 while the MOSFET is ON, and the current which flows through the inductor L2 from the flywheel diode D1 while the MOSFET is OFF flows through the RS.

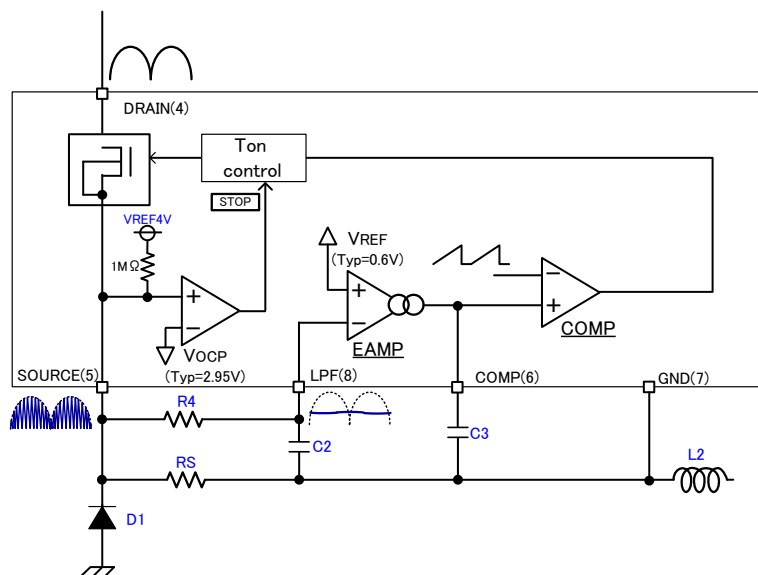


Figure 10. Diagram of Error Amplifier Block

(2.2) SOURCE Pin OCP

OCP (Over Current Protection) function is built-in SOURCE pin. When SOURCE pin voltage reached the detection voltage V_{OCP} (Typ=2.95V), MOSFET switches from ON to OFF. (Automatic Recovery Protection)

(2.3) L.E.B Blanking Period

When the internal MOSFET is turned ON, surge current occurs by the capacitive components and drive current. In this case, if the SOURCE pin voltage rises temporarily, false detections may occur in the OCP function. For preventing from the false detections, a L.E.B (Leading Edge Blanking) function which masks the SOURCE voltage during a constant time T_{LEB} (Typ=200ns) after MOSFET switches from OFF to ON is built in.

(2.4) SOURCE Pin Open Protection

When the SOURCE pin becomes open, this function stops the switching operation for protection. (Automatic Recovery Protection)

(3)Zero Current Detection Block (ZT : 1pin)

(3.1)Block Description

ZT pin controls the OFF time of the internal MOSFET gate signal. While the MOSFET is OFF, the current flows from the flywheel diode D1 to the inductor L2. While the current I_L is close to zero, the voltage of ZT pin falls down. While the voltage becomes lower than V_{ZT1} (Typ=110mV), it is detected by the ZT comparator, and the MOSFET turns to ON.

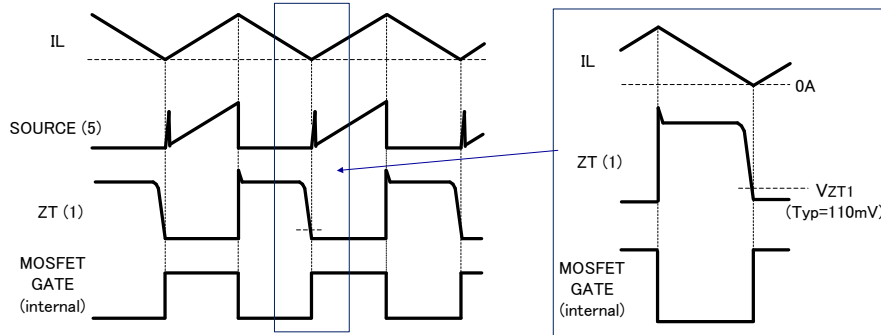


Figure 11. Zero-cross Detection by ZT Pin

(3.2) ZT Trigger Timeout

In case of the ZT pin is locked at low voltage which is caused by some malfunctions of the components on the application board, and the quasi-resonant switching operation stops, the MOSFET is forced to turn ON after T_{ZTOUT} (Typ=18μs).

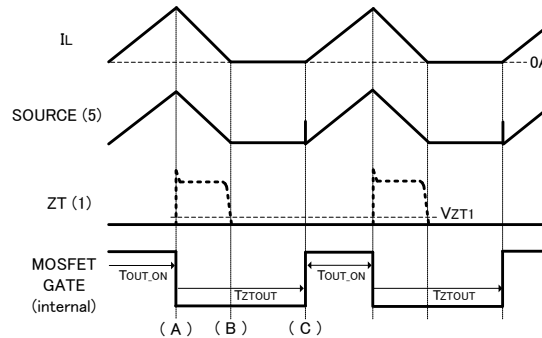


Figure 12. ZT Trigger Timeout Operation

(A)...When the ON time (T_{OUT_ON}) which is determined by the voltage of COMP pin passed, the MOSFET turns OFF.

(B)...The ZT pin is locked at a low voltage, so the MOSFET does not turn ON.

(C)...When T_{ZTOUT} passed after the MOSFET turns OFF, the MOSFET is forced to turn ON.

(3.3) Maximum Frequency

The maximum frequency is a function which is designed for preventing the overheating from of the IC, and it limits the IC to operate under the F_{MAX} (Typ=300kHz).

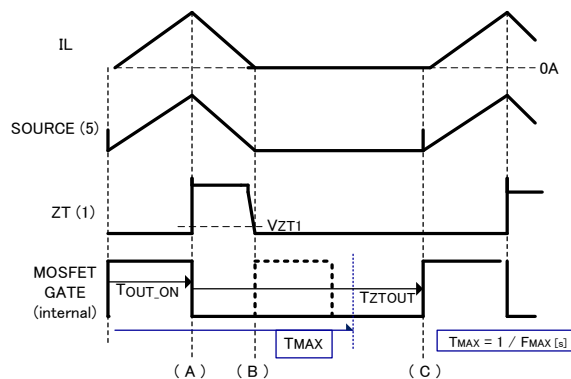


Figure 13. Maximum Frequency Operation

(A)...When the ON time (T_{OUT_ON}) which is determined by the voltage of COMP pin passed, the MOSFET turns OFF.

(B)...If the switching frequency exceeds the F_{MAX} , the MOSFET cannot turn ON.

(C)...When T_{ZTOUT} passed after the MOSFET turns OFF, the MOSFET is forced to turn ON.

Operation Mode of Protection Circuit

Operation mode of protection functions are shown in Table 2.

Table 2. Operation Mode of Protection Circuit

| Abnormal State Detection | | Detection | Release | Protection Operations |
|--------------------------|------|--|--|---------------------------------------|
| VCC | UVLO | $\leq 8.2\text{V(Typ)}$ | $\geq 13.5\text{V (Typ)}$ | IC Stops (Automatic Recovery) |
| | OVP | $\geq 27.5\text{V(Typ)}$ | Before Latch: $\leq 23.5\text{V (Typ)}$ Latched: $V_{CC} \leq 7.7\text{V (Typ)}$ | 150 $\mu\text{s(Typ)}$ Timer Latch |
| SOURCE | OCP | $\geq 2.95\text{V(Typ)}$ | $< 2.95\text{V (Typ)}$ | Output Stops (Automatic Recovery) |
| TSD | | $\geq 175\text{ }^{\circ}\text{C (Typ)}$ | Before Latch: $\leq 155\text{ }^{\circ}\text{C (Typ)}$ Latched: $V_{CC} \leq 7.7\text{V (Typ)}$ | 150 $\mu\text{s(Typ)}$ Timer Latch |

Operational Notes

1. Reverse Connection of Power Supply

Connecting the power supply in reverse polarity can damage the IC. Take precautions against reverse polarity when connecting the power supply, such as mounting an external diode between the power supply and the IC's power supply pins.

2. Power Supply Lines

Design the PCB layout pattern to provide low impedance supply lines. Separate the ground and supply lines of the digital and analog blocks to prevent noise in the ground and supply lines of the digital block from affecting the analog block. Furthermore, connect a capacitor to ground at all power supply pins. Consider the effect of temperature and aging on the capacitance value when using electrolytic capacitors.

3. Ground Voltage

Ensure that no pins are at a voltage below that of the ground pin at any time, even during transient condition.

4. Ground Wiring Pattern

When using both small-signal and large-current ground traces, the two ground traces should be routed separately but connected to a single ground at the reference point of the application board to avoid fluctuations in the small-signal ground caused by large currents. Also ensure that the ground traces of external components do not cause variations on the ground voltage. The ground lines must be as short and thick as possible to reduce line impedance.

5. Thermal Consideration

Should by any chance the maximum junction temperature rating be exceeded the rise in temperature of the chip may result in deterioration of the properties of the chip. In case of exceeding this absolute maximum rating, increase the board size and copper area to prevent exceeding the maximum junction temperature rating.

6. Recommended Operating Conditions

These conditions represent a range within which the expected characteristics of the IC can be approximately obtained. The electrical characteristics are guaranteed under the conditions of each parameter.

7. Inrush Current

When power is first supplied to the IC, it is possible that the internal logic may be unstable and inrush current may flow instantaneously due to the internal powering sequence and delays, especially if the IC has more than one power supply. Therefore, give special consideration to power coupling capacitance, power wiring, width of ground wiring, and routing of connections.

8. Operation Under Strong Electromagnetic Field

Operating the IC in the presence of a strong electromagnetic field may cause the IC to malfunction.

9. Testing on Application Boards

When testing the IC on an application board, connecting a capacitor directly to a low-impedance output pin may subject the IC to stress. Always discharge capacitors completely after each process or step. The IC's power supply should always be turned off completely before connecting or removing it from the test setup during the inspection process. To prevent damage from static discharge, ground the IC during assembly and use similar precautions during transport and storage.

10. Inter-pin Short and Mounting Errors

Ensure that the direction and position are correct when mounting the IC on the PCB. Incorrect mounting may result in damaging the IC. Avoid nearby pins being shorted to each other especially to ground, power supply and output pin. Inter-pin shorts could be due to many reasons such as metal particles, water droplets (in very humid environment) and unintentional solder bridge deposited in between pins during assembly to name a few.

Operational Notes – continued

11. Unused Input Terminals

Input pins of an IC are often connected to the gate of a MOS transistor. The gate has extremely high impedance and extremely low capacitance. If left unconnected, the electric field from the outside can easily charge it. The small charge acquired in this way is enough to produce a significant effect on the conduction through the transistor and cause unexpected operation of the IC. So unless otherwise specified, unused input pins should be connected to the power supply or ground line.

12. Regarding the Input Pin of the IC

This monolithic IC contains P+ isolation and P substrate layers between adjacent elements in order to keep them isolated. P-N junctions are formed at the intersection of the P layers with the N layers of other elements, creating a parasitic diode or transistor. For example (refer to figure below):

When $GND > Pin\ A$ and $GND > Pin\ B$, the P-N junction operates as a parasitic diode.

When $GND > Pin A$ and $GND > Pin B$, the P-N junction operates as a parasitic transistor.

Parasitic diodes inevitably occur in the structure of the IC. The operation of parasitic diodes can result in mutual interference among circuits, operational faults, or physical damage. Therefore, conditions that cause these diodes to operate, such as applying a voltage lower than the GND voltage to an input pin (and thus to the P substrate) should be avoided.

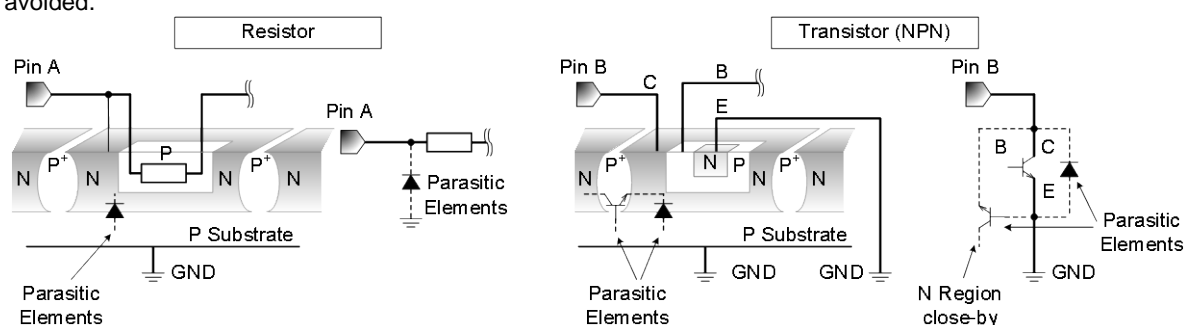


Figure 14. Example of monolithic IC structure

13. Ceramic Capacitor

When using a ceramic capacitor, determine the dielectric constant considering the change of capacitance with temperature and the decrease in nominal capacitance due to DC bias and others.

14. Area of Safe Operation (ASO)

Operate the IC such that the output voltage, output current, and the maximum junction temperature rating are all within the Area of Safe Operation (ASO).

15. Thermal Shutdown Circuit(TSD)

This IC has a built-in thermal shutdown circuit that prevents heat damage to the IC. Normal operation should always be within the IC's maximum junction temperature rating. If however the rating is exceeded for a continued period, the junction temperature (T_J) will rise which will activate the TSD circuit that will turn OFF all output pins. The IC should be powered down and turned ON again to resume normal operation because the TSD circuit keeps the outputs at the OFF state even if the T_J falls below the TSD threshold.

Note that the TSD circuit operates in a situation that exceeds the absolute maximum ratings and therefore, under no circumstances, should the TSD circuit be used in a set design or for any purpose other than protecting the IC from heat damage.

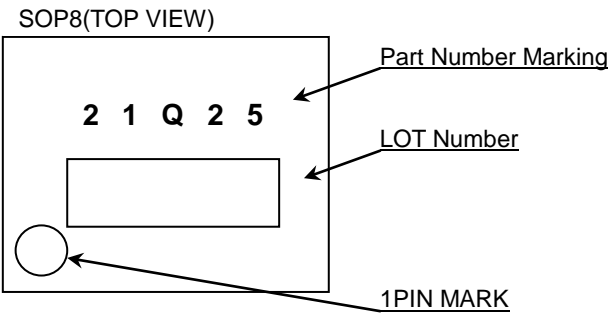
16. Over Current Protection Circuit (OCP)

This IC incorporates an integrated overcurrent protection circuit that is activated when the load is shorted. This protection circuit is effective in preventing damage due to sudden and unexpected incidents. However, the IC should not be used in applications characterized by continuous operation or transitioning of the protection circuit.

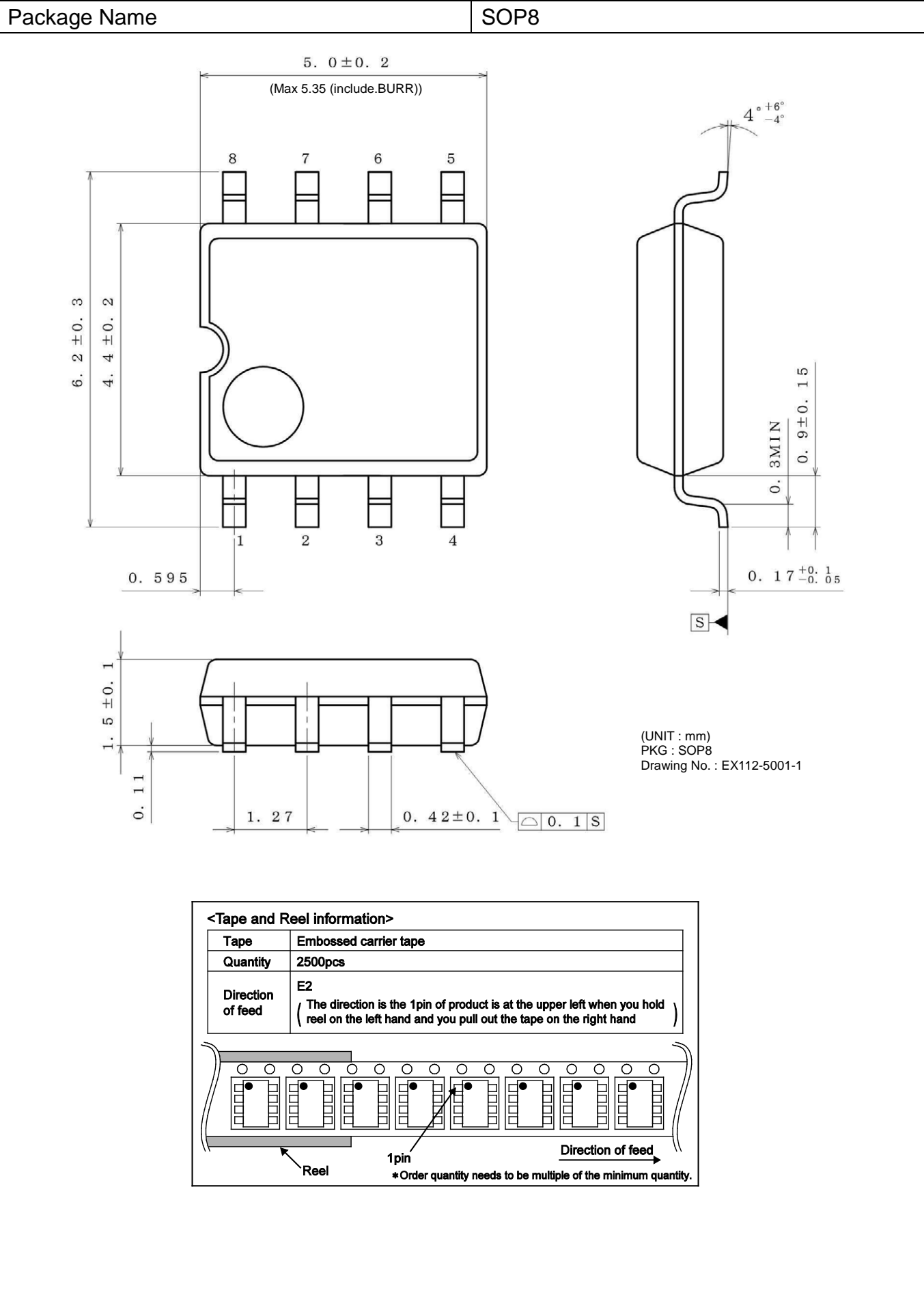
Ordering Information

| | | | | | | | | | | | |
|-------------------|--|--|--|--|--------------------|--|--|--|---|----|--|
| B M 5 2 1 Q 2 5 F | | | | | | | | | - | XX | |
| Product name | | | | | Package F: SOP8 | | | | Packaging and forming specification XX: Please confirm the formal name with our salesmen. | | |

Marking Diagram



Physical Dimension, Tape and Reel Information



Revision History

| Date | Revision | Changes |
|-------------|----------|---|
| 18.Jan.2016 | 001 | New Release |
| 20.Apr.2016 | 002 | P2 Footprints and Traces Changed the representation of the units. 74.2mm^2 (Square) \Rightarrow $74.2\text{mm} \times 74.2\text{mm}$ |

Notice

Precaution on using ROHM Products

- Our Products are designed and manufactured for application in ordinary electronic equipments (such as AV equipment, OA equipment, telecommunication equipment, home electronic appliances, amusement equipment, etc.). If you intend to use our Products in devices requiring extremely high reliability (such as medical equipment ^(Note 1), transport equipment, traffic equipment, aircraft/spacecraft, nuclear power controllers, fuel controllers, car equipment including car accessories, safety devices, etc.) and whose malfunction or failure may cause loss of human life, bodily injury or serious damage to property ("Specific Applications"), please consult with the ROHM sales representative in advance. Unless otherwise agreed in writing by ROHM in advance, ROHM shall not be in any way responsible or liable for any damages, expenses or losses incurred by you or third parties arising from the use of any ROHM's Products for Specific Applications.

(Note1) Medical Equipment Classification of the Specific Applications

| JAPAN | USA | EU | CHINA |
|-----------|-----------|------------|-----------|
| CLASS III | CLASS III | CLASS II b | CLASS III |
| CLASS IV | | CLASS III | |

- ROHM designs and manufactures its Products subject to strict quality control system. However, semiconductor products can fail or malfunction at a certain rate. Please be sure to implement, at your own responsibilities, adequate safety measures including but not limited to fail-safe design against the physical injury, damage to any property, which a failure or malfunction of our Products may cause. The following are examples of safety measures:
 - Installation of protection circuits or other protective devices to improve system safety
 - Installation of redundant circuits to reduce the impact of single or multiple circuit failure
- Our Products are designed and manufactured for use under standard conditions and not under any special or extraordinary environments or conditions, as exemplified below. Accordingly, ROHM shall not be in any way responsible or liable for any damages, expenses or losses arising from the use of any ROHM's Products under any special or extraordinary environments or conditions. If you intend to use our Products under any special or extraordinary environments or conditions (as exemplified below), your independent verification and confirmation of product performance, reliability, etc. prior to use, must be necessary:
 - Use of our Products in any types of liquid, including water, oils, chemicals, and organic solvents
 - Use of our Products outdoors or in places where the Products are exposed to direct sunlight or dust
 - Use of our Products in places where the Products are exposed to sea wind or corrosive gases, including Cl₂, H₂S, NH₃, SO₂, and NO₂
 - Use of our Products in places where the Products are exposed to static electricity or electromagnetic waves
 - Use of our Products in proximity to heat-producing components, plastic cords, or other flammable items
 - Sealing or coating our Products with resin or other coating materials
 - Use of our Products without cleaning residue of flux (even if you use no-clean type fluxes, cleaning residue of flux is recommended); or Washing our Products by using water or water-soluble cleaning agents for cleaning residue after soldering
 - Use of the Products in places subject to dew condensation
- The Products are not subject to radiation-proof design.
- Please verify and confirm characteristics of the final or mounted products in using the Products.
- In particular, if a transient load (a large amount of load applied in a short period of time, such as pulse. is applied, confirmation of performance characteristics after on-board mounting is strongly recommended. Avoid applying power exceeding normal rated power; exceeding the power rating under steady-state loading condition may negatively affect product performance and reliability.
- De-rate Power Dissipation depending on ambient temperature. When used in sealed area, confirm that it is the use in the range that does not exceed the maximum junction temperature.
- Confirm that operation temperature is within the specified range described in the product specification.
- ROHM shall not be in any way responsible or liable for failure induced under deviant condition from what is defined in this document.

Precaution for Mounting / Circuit board design

- When a highly active halogenous (chlorine, bromine, etc.) flux is used, the residue of flux may negatively affect product performance and reliability.
- In principle, the reflow soldering method must be used on a surface-mount products, the flow soldering method must be used on a through hole mount products. If the flow soldering method is preferred on a surface-mount products, please consult with the ROHM representative in advance.

For details, please refer to ROHM Mounting specification

Precautions Regarding Application Examples and External Circuits

1. If change is made to the constant of an external circuit, please allow a sufficient margin considering variations of the characteristics of the Products and external components, including transient characteristics, as well as static characteristics.
2. You agree that application notes, reference designs, and associated data and information contained in this document are presented only as guidance for Products use. Therefore, in case you use such information, you are solely responsible for it and you must exercise your own independent verification and judgment in the use of such information contained in this document. ROHM shall not be in any way responsible or liable for any damages, expenses or losses incurred by you or third parties arising from the use of such information.

Precaution for Electrostatic

This Product is electrostatic sensitive product, which may be damaged due to electrostatic discharge. Please take proper caution in your manufacturing process and storage so that voltage exceeding the Products maximum rating will not be applied to Products. Please take special care under dry condition (e.g. Grounding of human body / equipment / solder iron, isolation from charged objects, setting of ionizer, friction prevention and temperature / humidity control).

Precaution for Storage / Transportation

1. Product performance and soldered connections may deteriorate if the Products are stored in the places where:
 - [a] the Products are exposed to sea winds or corrosive gases, including Cl₂, H₂S, NH₃, SO₂, and NO₂
 - [b] the temperature or humidity exceeds those recommended by ROHM
 - [c] the Products are exposed to direct sunshine or condensation
 - [d] the Products are exposed to high Electrostatic
2. Even under ROHM recommended storage condition, solderability of products out of recommended storage time period may be degraded. It is strongly recommended to confirm solderability before using Products of which storage time is exceeding the recommended storage time period.
3. Store / transport cartons in the correct direction, which is indicated on a carton with a symbol. Otherwise bent leads may occur due to excessive stress applied when dropping of a carton.
4. Use Products within the specified time after opening a humidity barrier bag. Baking is required before using Products of which storage time is exceeding the recommended storage time period.

Precaution for Product Label

A two-dimensional barcode printed on ROHM Products label is for ROHM's internal use only.

Precaution for Disposition

When disposing Products please dispose them properly using an authorized industry waste company.

Precaution for Foreign Exchange and Foreign Trade act

Since concerned goods might be fallen under listed items of export control prescribed by Foreign exchange and Foreign trade act, please consult with ROHM in case of export.

Precaution Regarding Intellectual Property Rights

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General Precaution

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