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**MB39C602****High Power Factor
LED Driver IC for LED Lighting**

MB39C602 is a flyback type switching regulator controller IC. The LED current is regulated by controlling the switching on-time depending on the LED load.

It is most suitable for the general lighting applications, for example stocks of commercial and residential light bulbs and so on.

Features

- High power factor in Single Conversion
- Helps to achieve high efficiency and low EMI by detecting auxiliary transformer zero current
- Switching frequency setting depend on the FC pin current : 30 kHz to 120 kHz
- Control of the current of Primary Winding without the external sense resistor
- Built-in under voltage lock out function
- Built-in output over voltage protection function
- Built-in over temperature protection function
- Input voltage range VDD : 9 V to 20 V
- Input voltage range for LED lighting applications : AC110V_{RMS}, AC230V_{RMS}
- Package : SOP-8 (3.9 mm × 5.05 mm × 1.75 mm [Max])

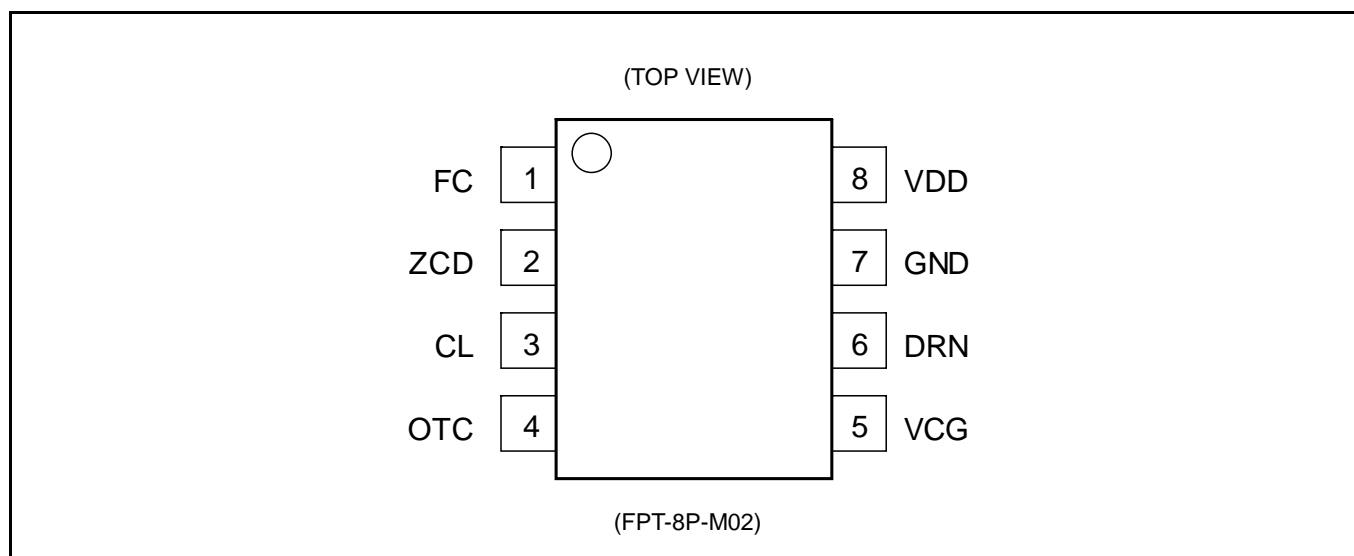
Applications

- LED lighting
- PWM dimmable LED lighting etc.

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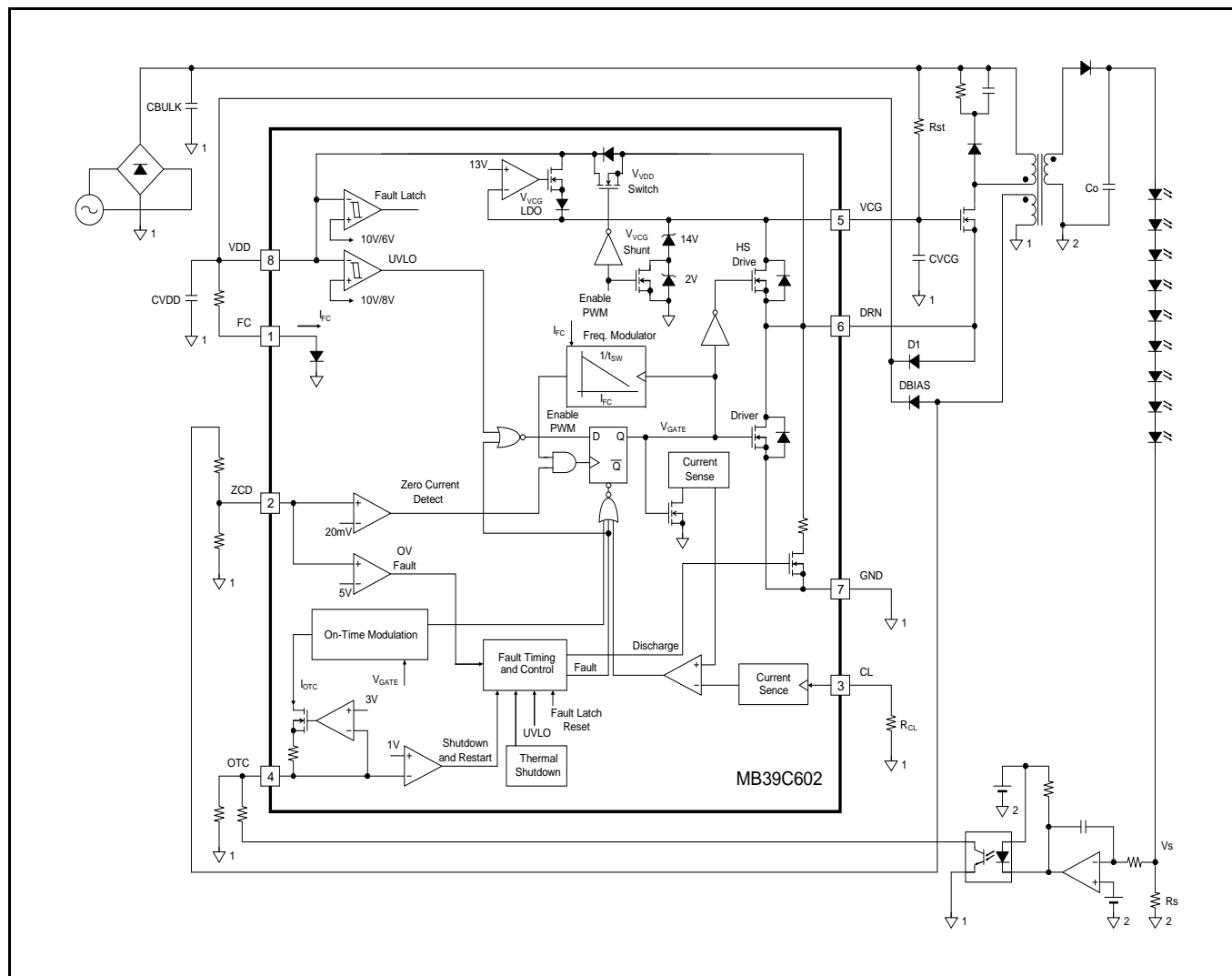
1. Pin Assignment



2. Pin Descriptions

| Pin No. | Pin Name | I/O | Description |
|---------|----------|-----|--|
| 1 | FC | I | Switching frequency setting pin. |
| 2 | ZCD | I | Transformer auxiliary winding zero current detecting pin. |
| 3 | CL | I | Pin for controlling peak current of transformer primary winding. |
| 4 | OTC | I | On-time control pin. |
| 5 | VCG | - | External MOSFET gate bias pin. |
| 6 | DRN | O | External MOSFET source connection pin. |
| 7 | GND | - | Ground pin. |
| 8 | VDD | - | Power supply pin. |

3. Block Diagram



4. Absolute Maximum Ratings

| Parameter | Symbol | Condition | Rating | | Unit |
|----------------------|------------------|--|--------|--------------------|------|
| | | | Min | Max | |
| Power supply voltage | V _{VDD} | VDD pin | -0.3 | +25.0 | V |
| Input voltage | V _{DRN} | DRN pin | - | 20 | V |
| | V _{VCG} | VCG pin | -0.3 | +16.0 | V |
| | V _{ZCD} | ZCD pin | -0.3 | +6.0 | V |
| | V _{OTC} | OTC pin | -0.3 | +6.0 | V |
| | V _{CL} | CL pin | -0.3 | +6.0 | V |
| | V _{FC} | FC pin | -0.3 | +2.0 | V |
| Input current | I _{VCG} | VCG pin | - | 10 | mA |
| | I _{OTC} | OTC pin | -1 | 0 | mA |
| | I _{CL} | CL pin | -1 | 0 | mA |
| | I _{FC} | FC pin | 0 | 1 | mA |
| Output current | I _{DRN} | DRN pin | - | 800 | mA |
| | I _{DRN} | DRN pin, Pulsed 400 ns, 2% duty cycle | -1.5 | +6.0 | A |
| Power dissipation | P _D | T _a ≤ +25°C | - | 800 ^[1] | mW |
| Storage temperature | T _{STG} | | -55 | +125 | °C |

[1]: The value when using two layers PCB.

Reference: θ_{ja} (wind speed 0 m/s): +125°C/W

WARNING:

Semiconductor devices may be permanently damaged by application of stress (including, without limitation, voltage, current or temperature) in excess of absolute maximum ratings.

Do not exceed any of these ratings.

5. Recommended Operating Conditions

| Parameter | Symbol | Condition | Value | | | Unit |
|---|-----------|---|-------|-----|-------|-------------|
| | | | Min | Typ | Max | |
| VDD pin input voltage | VDD | VDD pin | 9 | - | 20 | V |
| VCG pin input voltage | VCG | VCG pin (from low-impedance source) | 9 | - | 13 | V |
| VCG pin input current | I_{VCG} | VCG pin (from high-impedance source) | 10 | - | 2000 | μA |
| OTC pin resistance to GND | R_{OTC} | OTC pin | 10 | - | 100 | k Ω |
| CL pin resistance to GND | R_{CL} | CL pin | 24.3 | - | 200.0 | k Ω |
| ZCD pin resistance to auxiliary winding | R_{ZCD} | ZCD pin Transformer auxiliary winding connection resistor | 50 | - | 200 | k Ω |
| VCG pin capacitance to GND | C_{VCG} | VCG pin | 33 | - | 200 | nF |
| VDD pin bypass capacitance | C_{BP} | Ceramic capacitance to set between VDD and GND pin | 0.1 | - | 1.0 | μF |
| Operating ambient temperature | Ta | - | -40 | +25 | +85 | $^{\circ}C$ |

WARNING:

The recommended operating conditions are required in order to ensure the normal operation of the semiconductor device. All of the device's electrical characteristics are warranted when the device is operated under these conditions.

Any use of semiconductor devices will be under their recommended operating condition.


Operation under any conditions other than these conditions may adversely affect reliability of device and could result in device failure.

No warranty is made with respect to any use, operating conditions or combinations not represented on this data sheet. If you are considering application under any conditions other than listed herein, please contact sales representatives beforehand.

6. Electrical Characteristics

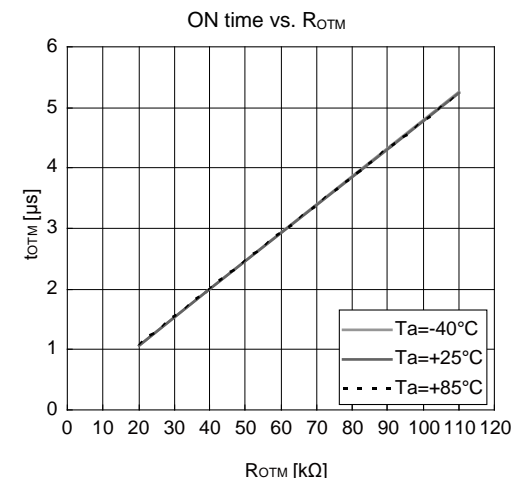
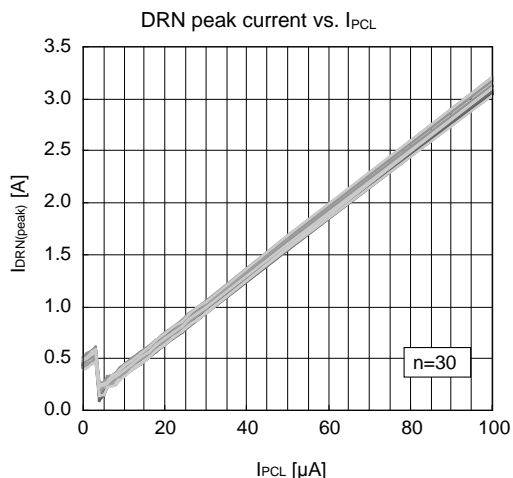
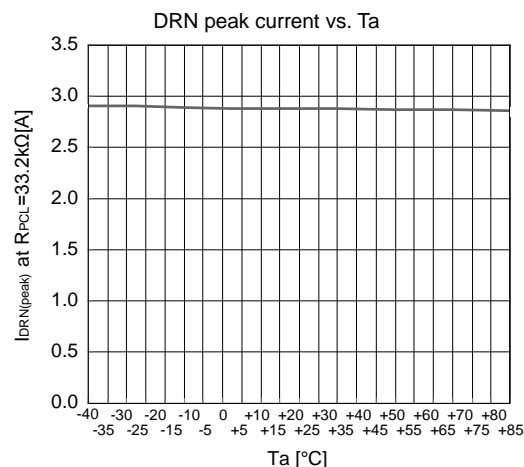
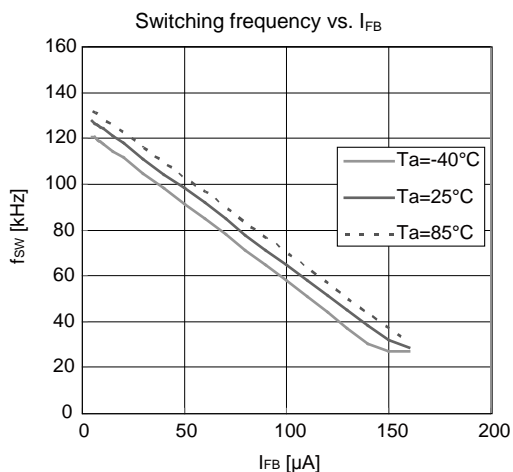
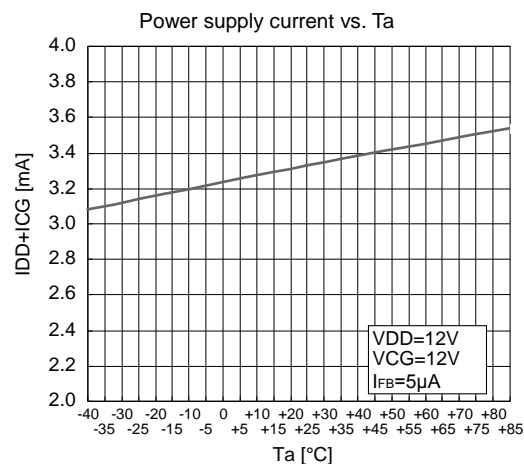
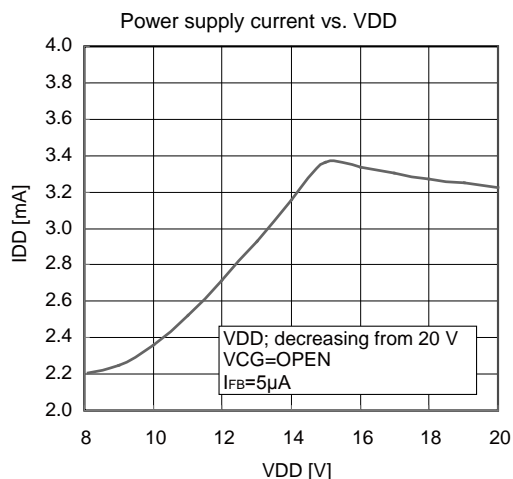
(Ta = +25°C, V_{VDD} = 12 V)

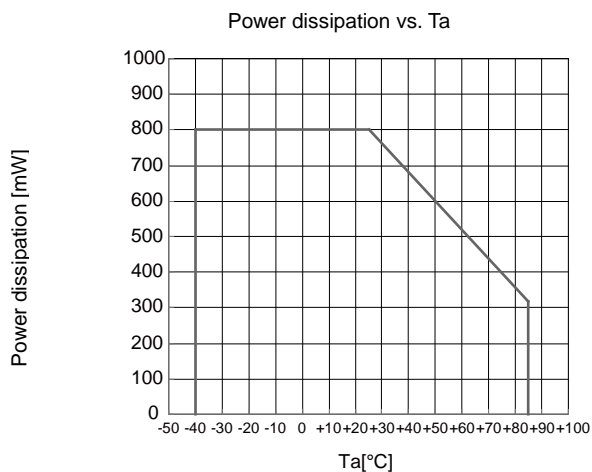
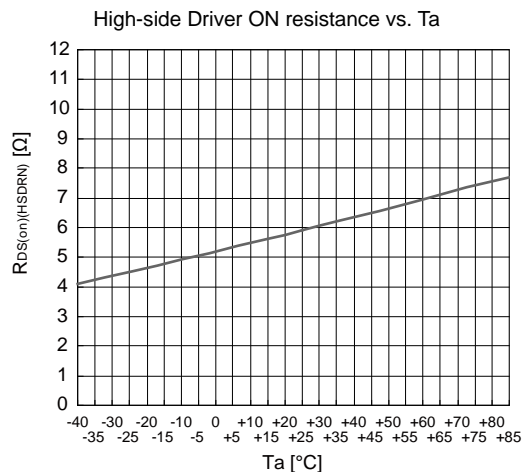
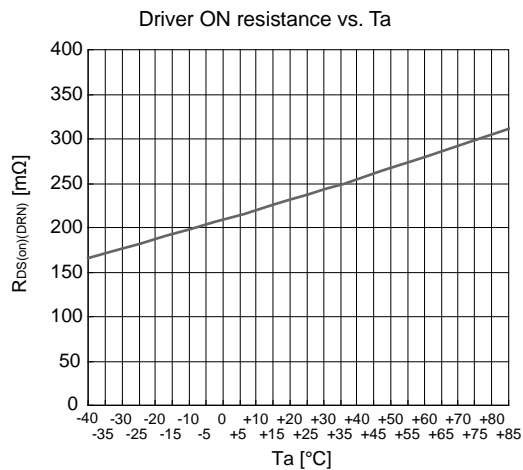
| Parameter | | Symbol | Pin No. | Condition | Value | | | Unit |
|--------------------|---|---------------------------------|---------|---|---------------------|---------------------|---------------------|------|
| | | | | | Min | Typ | Max | |
| VDD and VCG SUPPLY | VCG voltage (Operating) | VCG _(OPERATING) | 5 | V _{VDD} = 14 V, I _{VCG} = 2.0 mA | 13 | 14 | 15 | V |
| | VCG voltage (Disable) | VCG _(DISABLED) | 5 | V _{OTC} = 0 V, I _{VCG} = 26 μA | 15 | 16 | 17 | V |
| | VCG voltage difference | ΔVCG | 5 | VCG _(DISABLED) - VCG _(OPERATING) | 1.75 | 2.00 | 2.15 | V |
| | VCG Shunt input current | I _{VCG (SREG)} | 5 | V _{VCG} = VCG _(DISABLED) - 100 mV, V _{OTC} = 0 V | - | 12 | 26 | μA |
| | VCG Shunt Load Regulation | ΔVCG _(SREG) | 5 | V _{OTC} = 0V, 26 μA < I _{VCG} ≤ 5 mA | - | 125 | 200 | mV |
| | VCG LDO regulation voltage | VCG _(LREG) | 5 | V _{VDD} = 20 V, I _{VCG} = -2 mA | - | 13 | - | V |
| | VCG LDO Dropout voltage | VCG _(LREG, DO) | - | VDD - VCG, V _{VDD} = 11 V, I _{VCG} = -2 mA | - | 2.0 | 2.8 | V |
| | UVLO Turn-on threshold voltage | VDD _(ON) | 8 | - | 9.7 | 10.2 | 10.7 | V |
| | UVLO Turn-off threshold voltage | VDD _(OFF) | 8 | - | 7.55 | 8.00 | 8.50 | V |
| | UVLO hysteresis | ΔVDD _(UVLO) | 8 | VDD _(ON) - VDD _(OFF) | 1.9 | 2.2 | 2.5 | V |
| | VDD switch on-resistance | R _{DS, ON (VDD)} | 6,8 | V _{VCG} = 12 V, V _{VDD} = 7 V, I _{DRN} = 50 mA | - | 4 ^[1] | 10 ^[1] | Ω |
| | Fault Latch Reset VDD voltage | VDD _(FAULT RESET) | 8 | - | 5.6 | 6.0 | 6.4 | V |
| MODULATION | Minimum switching period | t _{SW (HF)} | 6 | I _{FC} = 5 μA | 7.215 | 7.760 | 8.305 | μs |
| | Maximum switching period | t _{SW (LF)} | 6 | I _{FC} = 165 μA | 31.5 ^[1] | 35.0 ^[1] | 38.5 ^[1] | μs |
| | DRN peak current | I _{DRN (peak)} | 6 | I _{FC} = 5 μA, I _{CL} = 100 μA | - | 3 ^[1] | - | A |
| | | | 6 | I _{FC} = 5 μA, I _{CL} = 30 μA | - | 1 ^[1] | - | A |
| | Minimum peak current for R _{CL} open | I _{DRN (peak, absmin)} | 6 | R _{CL} = OPEN | - | 0.45 ^[1] | - | A |
| | ILIM blanking time | t _{BLANK (ILIM)} | 6 | I _{FC} = 5 μA, R _{CL} = 100 kΩ, 1.2 A pull-up on DRN | - | 400 ^[1] | - | ns |
| | CL voltage | V _{CL} | 3 | I _{FC} = 5 μA | 2.94 | 3.00 | 3.06 | V |
| DRIVER | FC voltage | V _{FC} | 1 | I _{FC} = 10 μA | 0.34 | 0.70 | 0.84 | V |
| | Driver on-resistance | R _{DS (on) (DRN)} | 6,7 | I _{DRN} = 4.0 A | - | 200 ^[1] | 400 ^[1] | mΩ |
| | Driver off leakage current | I _{DRN (OFF)} | 6,7 | V _{DRN} = 12 V | - | 1.5 | 20.0 | μA |
| | High-side driver on-resistance | R _{DS (on) (HSDRV)} | 5,6 | High-side driver current = 50 mA | - | 6 ^[1] | 11 ^[1] | Ω |
| | DRN discharge current | I _{DIS} | 6,7 | VDD = OPEN, DRN = 12 V, Fault latch set | 2.38 | 3.40 | 4.42 | mA |

| Parameter | | Symbol | Pin No. | Condition | Value | | | Unit |
|------------------------------------|---|----------------------|---------|--|------------------|---------------------|--------------------|-------------|
| | | | | | Min | Typ | Max | |
| TRANSFORMER ZERO CURRENT DETECTION | Zero current threshold voltage | $V_{ZCD(TH)}$ | 2 | - | 5 ^[1] | 20 ^[1] | 50 ^[1] | mV |
| | Clamp voltage | $V_{ZCD(CLAMP)}$ | 2 | $I_{ZCD} = -10 \mu A$ | -200 | -160 | -100 | mV |
| | Start timer operation threshold voltage | $V_{ZCD(START)}$ | 2 | - | 0.10 | 0.15 | 0.20 | V |
| | Driver turn-on Delay time | $t_{DLY(ZCD)}$ | 6 | 150 Ω pull-up 12 V on DRN | - | 150 | - | ns |
| | Wait time for zero current detection | $t_{WAIT(ZCD)}$ | 6 | - | 2.0 | 2.4 | 2.8 | μs |
| | Start timer period | t_{ST} | 6 | $V_{ZCD} = 0 V$ | 150 | 240 | 300 | μs |
| OVERVOLTAGE FAULT | OVP threshold voltage | $V_{ZCD(OVP)}$ | 2 | - | 4.85 | 5.00 | 5.15 | V |
| | OVP blanking time | $t_{BLANK, OVP}$ | 6 | - | 0.6 | 1.0 | 1.7 | μs |
| | Input bias current | $I_{ZCD(bias)}$ | 2 | $V_{ZCD} = 5 V$ | -0.1 | 0 | +0.1 | μA |
| SHUTDOWN THRESHOLD | Shutdown Threshold voltage | $V_{OTC(Vth)}$ | 4 | OTC =  | 0.7 | 1.0 | 1.3 | V |
| | Shutdown OTC current | $I_{OTC, PU}$ | 4 | $V_{OTC} = V_{OTC(Vth)}$ | -600 | -450 | -300 | μA |
| MAXIMUM ON TIME | ON-Time | t_{OTC} | 6 | $R_{OTC} = 76 k\Omega$ | 3.4 | 3.8 | 4.2 | μs |
| | OTC voltage | V_{OTC} | 4 | - | 2.7 | 3.0 | 3.3 | V |
| OTP | Shutdown temperature | T_{SD} | - | T_J , temperature rising | - | +150 ^[1] | - | $^{\circ}C$ |
| | Hysteresis | T_{SD_HYS} | - | T_J , temperature falling, degrees below T_{SD} | - | +25 ^[1] | - | $^{\circ}C$ |
| POWER SUPPLY CURRENT | Power supply current | $I_{VDD(STATIC)}$ | 8 | $V_{VDD} = 20 V, V_{ZCD} = 1 V$ | 1.36 | 1.80 | 2.34 | mA |
| | | $I_{VDD(OPERATING)}$ | 8 | $V_{VDD} = 20 V$ | - | 3.0 ^[1] | 3.7 ^[1] | mA |
| | Power supply current for UVLO | $I_{VDD(UVLO)}$ | 8 | $V_{VDD} = V_{DD(ON)} - 100 mV$ | - | 285 | 500 | μA |

[1]: Standard design value

7. Typical Characteristics





8. Function Explanation

1. LED Current Control Function

MB39C602 is a flyback type switching regulator controller. The LED current is regulated by controlling the switching on-time depending on the LED load. The LED current is converted into detecting voltage (V_s) by sense resistor (R_s) connected in series with LED. V_s is compared by an external error amplifier (Err AMP). When V_s falls below a reference voltage, Err AMP output rises and the current that flows into the Opto-Coupler is decreased.

The OTC pin current is controlled via the Opto-Coupler in the on-time control block. In on-time control, it controls on-time at OTC pin current. So, on-time increases when the current of the OTC pin decreases. And the average current supplied to LED is regulated, because on-time is regulated at the constant switching frequency.

2. Cascode Switching

The switch in Primary Winding is a cascode connection. The gate of external MOSFET is connected with the VCG pin, and the source is connected with the drain of internal Driver MOSFET. When the switch is on-state, internal Driver MOSFET is turned on, HS Driver MOSFET is turned off, and the source voltage of external MOSFET goes down to GND. For this period the DC bias is supplied to the gate of external MOSFET from the VCG pin. Therefore external MOSFET is turned on.

When the switch is off-state, internal Driver MOSFET is turned off, HS Driver MOSFET is turned on, and the source voltage of external MOSFET goes up to VCG voltage. For this period the DC bias is supplied to the gate of external MOSFET from the VCG pin. Therefore external MOSFET is turned off. Moreover, the current flowing into internal Driver MOSFET is equal to the current of Primary Winding. Therefore, the peak current into Primary Winding can be detected without the sense resistor.

3. Natural PFC (Power Factor Correction) Function

In the AC voltage input, when the input current waveform is brought close to the sine-wave, and the phase difference is brought close to Zero, Power Factor is improved. In the flyback method operating in discontinuous conduction mode, when the input capacitance is set small, the input current almost becomes equal with peak current (I_{PEAK}) of Primary Winding.

$$I_{PEAK} = \left(\frac{V_{BULK} \times t_{ON}}{L_{MP}} \right) = \left(\frac{V_{BULK}}{\left(\frac{L_{MP}}{t_{ON}} \right)} \right)$$

V_{BULK} : Supply voltage of Primary Winding

L_{MP} : Inductance of Primary Winding

t_{ON} : On-time

In on-time control, if loop response of Error Amp. is set to lower than the AC frequency (below 1/10 of the AC frequency), on-time can be constant. Therefore, input current is proportional to input voltage, so Power Factor is regulated.



MB39C602

4. Power-Up Sequencing

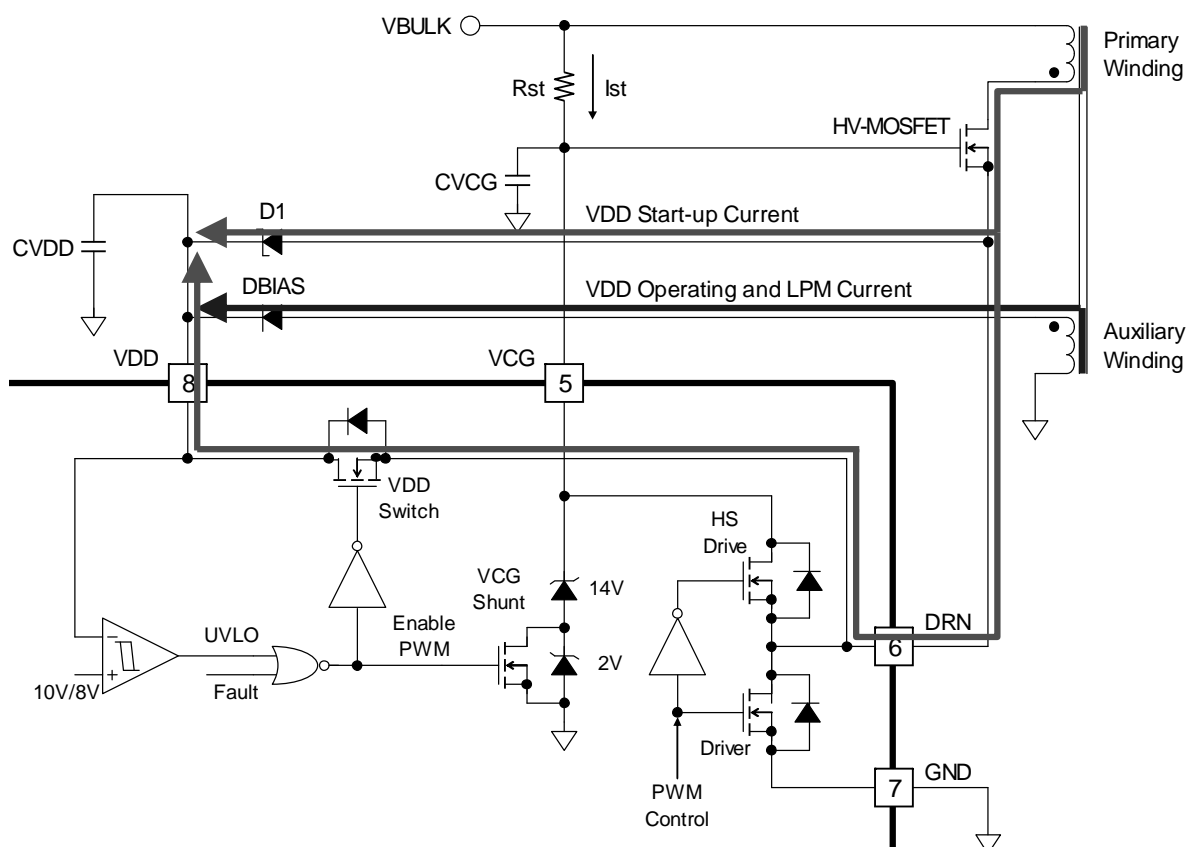
When the voltage is input to VBULK, the electric charge is charged to capacitance of the VCG pin (CVCG) through starting resistor (Rst). So, the voltage of the VCG pin rises. The voltage of the DRN pin rises by source follower when the voltage of the VCG pin reaches the threshold voltage of the external HVMOSFET.

The DRN pin is connected with the VDD pin through the internal VDD Switch, and VDD capacitor (CVDD) is charged from the DRN pin. When the voltage at the VDD pin reaches the threshold voltage of UVLO, the VDD Switch is turned off, and the internal Bias circuit operates, and the switching is started.

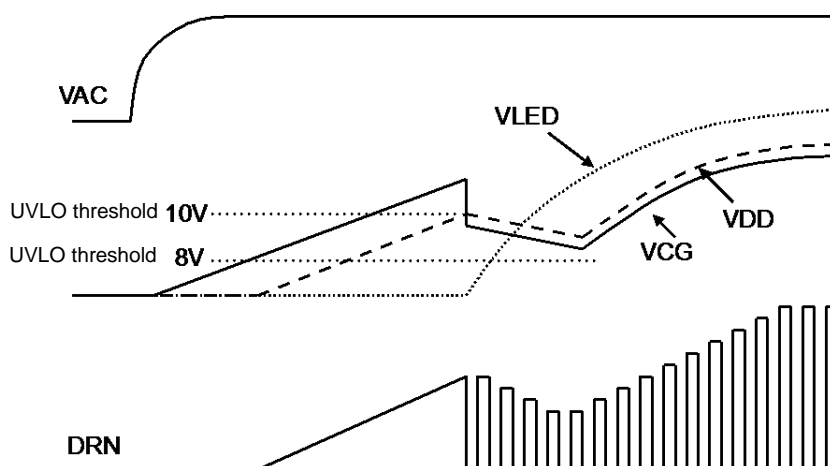
After the switching begins, the voltage at the VDD pin is supplied from Auxiliary Winding through the external diode (DBIAS). The voltage of an Auxiliary Winding is decided by rolling number ratio of Auxiliary Winding and Secondary Winding, and the voltage of Secondary Winding. Therefore, the voltage at the VDD pin is not supplied, until the voltage of Auxiliary Winding rises more than the voltage at the VDD pin. In this period, it is necessary to set the capacitor of the VDD pin to prevent the voltage of the VDD pin from falling below the threshold voltage of UVLO.

The external Schottky diode (D1) is required between the DRN pin and VDD pin. This diode is used to prevent the current that flows through the body diode of the VDD Switch.

- Current Passing When Starting



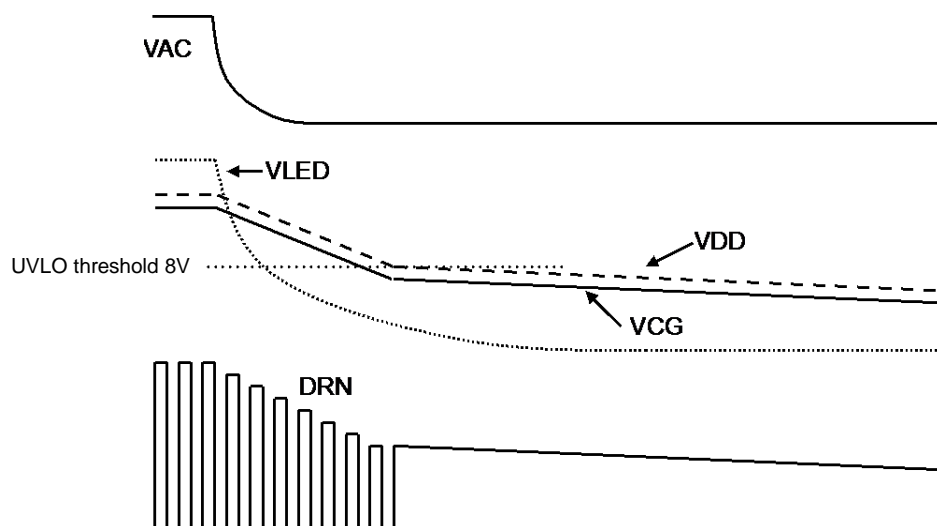
• Power-Up Sequencing



5. Power Down Sequencing

When AC power is removed from the AC line, the current does not flow to Secondary Winding even if HV MOSFET is switching. The LED current is supplied from the output capacitance and decreases gradually. Similarly, the voltage at the VDD pin decreases because the current does not flow into Auxiliary Winding. The switching stops and MB39C602 becomes shutdown when the voltage at the VDD pin falls below the threshold voltage of UVLO.

• Power Down Sequencing

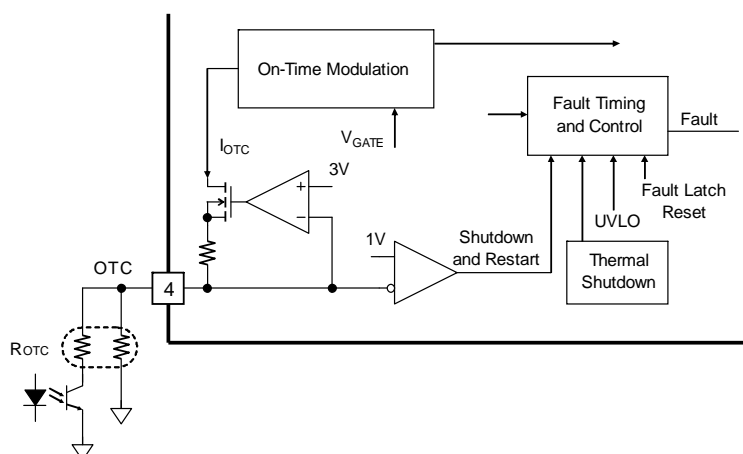


6. OTC Part

It is set on-time by connecting resistance (R_{OTC}) with OTC pin.

As shown in following figure, the on-time can be controlled by connecting the collector of the Opto-Coupler through resistor from OTC.

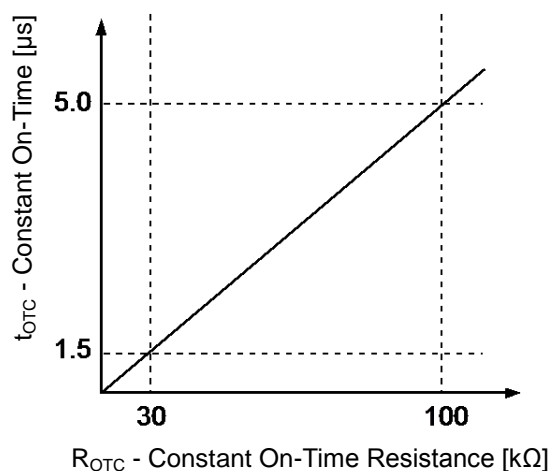
• OTC pin Control



The following figure shows how the on-time is programmed over the range of between 1.5 μ s and 5.0 μ s for either range of programming resistors. On-time is related to the programmed resistor based on the following equations.

$$R_{OTC} = t_{OTC} \times (2 \times 10^{10} \left[\frac{\Omega}{s} \right])$$

• On-time Setting Range



Moreover, it can be shutted down by making the voltage of the OTC pin below " $V_{OTC(Vth)}$ (typ 1V)".

7. CL Part

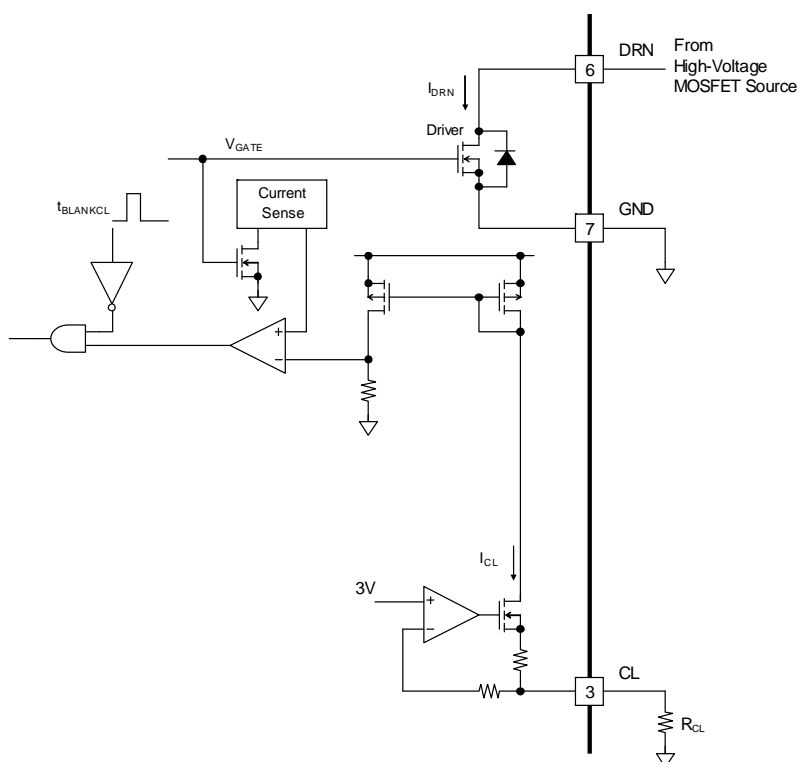
It is set the peak current of Primary Winding by connecting resistance with CL pin.

The maximum peak current of Primary Side is set by connecting resistance (R_{CL}) between the CL pin and GND.

$$I_{DRN(pk)} = \left(\frac{100kV}{R_{CL}} \right)$$

An about 400 ns blanking time of the beginning of switching cycle is masking the spike noise. As a result, it prevents the sense of current from malfunctioning (See the figure below.).

• Peak Current Control with CL pin

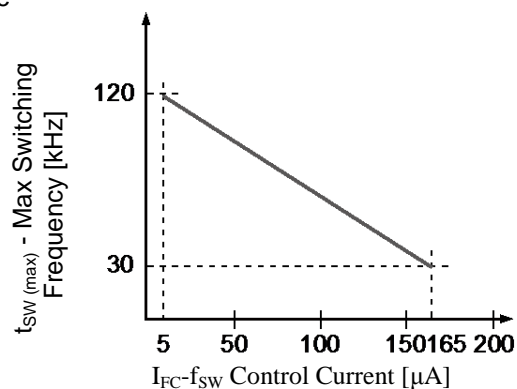


8. FC Part

The switching frequency is controlled by setting the current of the FC pin. In on-time control, the switching frequency is set by pulling up the FC pin to VDD.

Switching frequency range is from 30 kHz to 120 kHz.

• Switching Frequency Range



9. ZCD Part

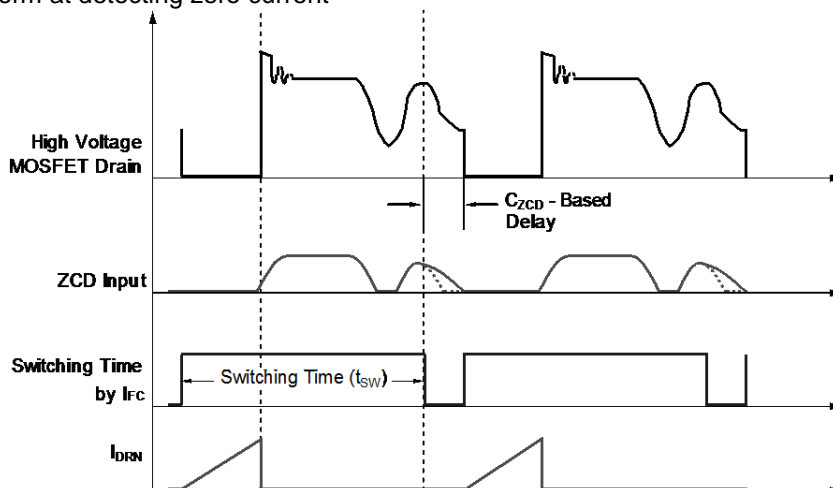
MB39C602 requires the following two conditions in order to start the next switching cycle.

- (1) The time since the last turn-on edge must be equal to or longer than the switching time set by I_{FC} .
- (2) Immediately after zero current detection at ZCD pin. Or, the time since the last zero current detection must be longer than $t_{WAIT(ZCD)}$ (2.4 μ s or less).

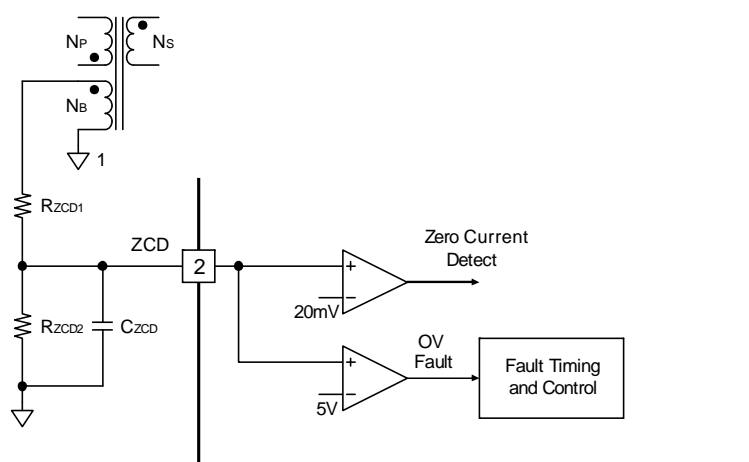
The ZCD pin is connected with Auxiliary Winding of the transformer through the resistance division, and detects zero current as shown below.

A delay, 50 ns to 200 ns, can be added with C_{ZCD} to adjust the turn-on of the primary switch with the resonant bottom of Primary Winding waveform.

• Switching Waveform at detecting zero current



• ZCD pin Connection



9. Various Protection Circuits

■ Under voltage lockout protection (UVLO)

The under voltage lockout protection (UVLO) protects IC from malfunction and protects the system from destruction/deterioration during the transient state and momentary drop due to start up for the power supply pin voltage (VDD). The voltage decrease of the VDD pin is detected with comparator, and output HS DRIVER is turned off and output DRIVER is turned off, and the switching is stopped. The system returns if the VDD pin becomes more than the threshold voltage of the UVLO circuit.

■ Output over voltage Protection (OVP)

When LED is in the state of open and the output voltage rises too much, the voltage of Auxiliary Winding and the voltage of the ZCD pin rise. The over voltage is detected by sampling this voltage of the ZCD pin.



When ZCD pin voltage rises more than the threshold voltage of OVP, the over voltage is detected. Output HS DRIVER is turned off, and output DRIVER is turned off, and the switching is stopped. (latch-off)

If the VDD pin becomes below the voltage of Fault Latch Reset, OVP is released.

■ Over temperature protection (OTP)

The over temperature protection (OTP) is a function to protect IC from the thermal destruction. When the junction temperature reaches +150°C, output HS DRIVER is turn off, and output DRIVER is turned off, and the switching is stopped. It returns again when the junction temperature falls to +125°C (automatic recovery).

10. Various Function Tables

| Function | DRN | | | | Detection Condition at Protected Operation | Return Condition | Remarks |
|---|---|---|--------|--------------|--|--------------------------|-----------|
| | LS_DRV | HS_DRV | VDD SW | Discharge SW | | | |
| Normal Operation |  |  | OFF | OFF | - | - | - |
| Under Voltage Lockout Protection (UVLO) | OFF | OFF | ON | OFF | VDD < 8.0 V | VDD > 10.2 V | Standby |
| OTC Shutdown | OFF | OFF | ON | OFF | OTC = GND | OTC > 1 V | Standby |
| Output Over Voltage Protection (OVP) | OFF | OFF | ON | ON | ZCD > 5 V | VDD < 6 V → VDD > 10.2 V | Latch-off |
| Over Temperature Protection (OTP) | OFF | OFF | ON | OFF | T _j > +150°C | T _j < +125°C | - |

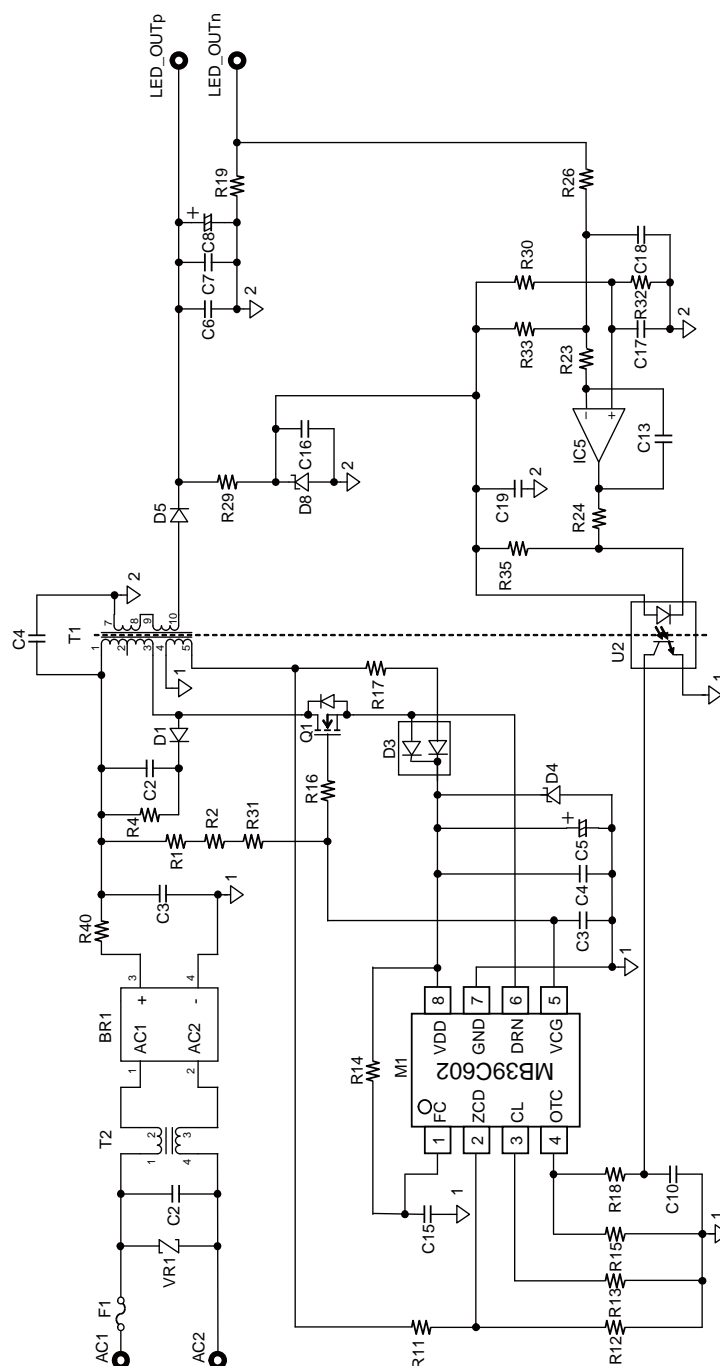
11. I/O Pin Equivalent Circuit Diagram

| Pin No. | Pin Name | Equivalent Circuit Diagram |
|---------|----------|----------------------------|
| 1 | FC | |
| 2 | ZCD | |
| 3 | CL | |

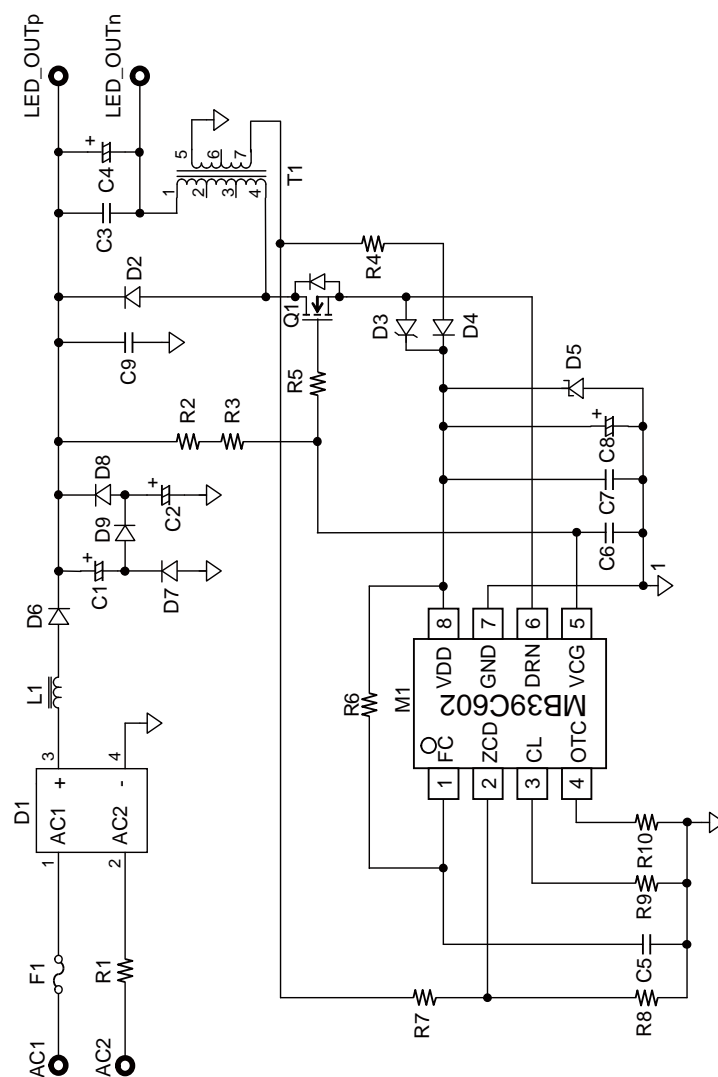
| Pin No. | Pin Name | Equivalent Circuit Diagram |
|---------|----------|----------------------------|
| 4 | OTC | |
| 5 | VCG | |
| 6 | DRN | |

12. Example Application Circuit

1. Isolation circuit



2. Non-isolation circuit



Part list

1. Isolation circuit

| No | Component | Description | Part No. | Vendor |
|----|----------------------------|---|--------------------|-------------------|
| 1 | M1 | IC PWM CTRLR CASCODE 8-SOIC | MB39C602 | Cypress |
| 2 | T1 | TRANSFORMER FLYBACK EE20/10/6 430 μ H 1.6 A RATIO Np/Ns=2.91/1 Np/Na=6.4/1 | 750811146 | Würth |
| 3 | T2 | IND COMMON MODE CHOKE 40 mH | 750311650 | Würth |
| 4 | F1 | Fuse, axial, fast acting, 2.5 A, 250 V, 0.160 x 0.400 inch | 026302.5MXL | Littelfuse Inc |
| 5 | IC5 | IC OPAMP GP R-R 1MHz SGL SOT23-5 | LMV321IDBVR | Texas Instruments |
| 6 | Q1 | MOSFET N-ch 650 V 7.3 A TO-220 FP | SPA07N60C3 | Infineon |
| 7 | U2 | OPTO ISOLATOR TRANSISTOR OUTPUT | PS2561L-1-A | CEL |
| 8 | BR1 | IC RECT BRIDGE 0.5 A 600 V 4SOIC | MB6S | Fairchild |
| 9 | D1 | DIODE ULTRA FAST 800 V 1 A SMA | RS1K-13-F | Diodes |
| 10 | D3 | DIODE ULTRA FAST 200 V SOT-23 | MMBD1404 | Fairchild |
| 11 | D4 | DIODE ZENER 18 V 225 mW SOT-23 | BZX84C18LT1G | On Semi |
| 12 | D5 | DIODE GPP FAST 1 A 600 V DO-41 | UF4005 | Fairchild |
| 13 | D8 | SHUNT REGULATOR 5.0 V SOT-23 | LM4040C50IDBZT | Texas Instruments |
| 14 | VR1 | SUR ABSORBER 7 mm 430 V 1250 A ZNR | ERZ-V07D431 | Panasonic |
| 15 | C2 | CAP CER 15000 pF 250 V X7R 1206 | GRM31BR72E153KW01L | muRata |
| 16 | C3 | CAP CER 10000 pF 50 V X7R 0603 | GRM188R71H103KA01D | muRata |
| 17 | C4 | CAP CER .1 μ F 25 V X7R 10% 0603 | GRM188R71E104KA01D | muRata |
| 18 | C5 | CAP 100 μ F 25 V ELECT RADIAL 2.5 mm | EKMG250ELL101MF11D | Nippon Chemi-con |
| 19 | C6, C7 | CAP CER 2.2 μ F 100 V X7R 1210 | GRM32ER72A225KA35 | muRata |
| 20 | C8 | CAP 1000 μ F 50 V ELECT HE RADIAL | EKMG500ELL102MK25S | Nippon Chemi-con |
| 21 | C9 | CAP .022 μ F/630 VDC METAL POLY | ECQE6223KF | Panasonic |
| 22 | C10, C15, C17, C18, C19 | CAP CER 10000 pF 50 V X7R 0603 | GRM188R71H103KA01D | muRata |
| 23 | C11 | CAP CER 2.2 nF X1/Y1 RADIAL | DE1E3KX222MA4BL01 | muRata |
| 24 | C13 | CAP CER 0.33 μ F 16 V X7R 0603 | C0603C334K4RACTU | Kemet |
| 25 | C16 | CAP CER .1 μ F 25 V 0805 | GRM21BR71E104KA0 | muRata |
| 26 | C21 | CAP .022 μ F/305 VAC X2 METAL POLYPRO | B32921C3223M | Epcos |
| 27 | R1, R2, R31 | RES 560 k Ω 1/4W 1% 1206 SMD | RK73H2BTTD5603F | KOA |
| 28 | R4 | RES 75.0 k Ω 1/4 W 1% 1206 SMD | RK73H2BTTD7502F | KOA |
| 29 | R11 | RES 110 k Ω , 1/8 W, 1%, 0603 SMD | RK73H1JTTD1103F | KOA |
| 30 | R12 | RES 33 k Ω 1/10 W 1% 0603 SMD | RK73H1JTTD3302F | KOA |

MB39C602

| No | Component | Description | Part No. | Vendor |
|----|-----------|--------------------------------|-----------------|-----------|
| 31 | R13 | RES 39 kΩ 1/10 W 1% 0603 SMD | RK73H1JTTD3902F | KOA |
| 32 | R14, R30 | RES 620 kΩ 1/10 W 1% 0603 SMD | RK73H1JTTD6203F | KOA |
| 33 | R15 | RES 100 kΩ 1/10 W 1% 0603 SMD | RK73H1JTTD1003F | KOA |
| 34 | R16 | RES 5.1 Ω 1/10 W 1% 0603 SMD | RK73H1JTTD5R10F | KOA |
| 35 | R17 | RES 3 Ω 1/8 W 1% 0805 SMD | RK73H2ATTD3R00F | KOA |
| 36 | R18 | RES 10.0 kΩ 1/10 W 1% 0603 SMD | RK73H1JTTD1002F | KOA |
| 37 | R19 | RES .33 Ω 1/4 W 1% 1206 SMD | ERJ-8RQFR33V | Panasonic |
| 38 | R23 | RES 20 kΩ 1/10 W 1% 0603 SMD | RK73H1JTTD2002F | KOA |
| 39 | R24, R35 | RES 3 kΩ 1/10 W 1% 0603 SMD | RK73H1JTTD3001F | KOA |
| 40 | R33 | RES 1.00 MΩ 1/10 W 1% 0603 SMD | RK73H1JTTD1004F | KOA |
| 41 | R26 | RES 2.00 kΩ 1/10 W 1% 0603 SMD | RK73H1JTTD2001F | KOA |
| 42 | R29 | RES 12 kΩ 1/10 W 1% 0603 SMD | RK73H1JTTD1202F | KOA |
| 43 | R32 | RES 18 kΩ 1/10 W 1% 0603 SMD | RK73H1JTTD1802F | KOA |
| 44 | R40 | JUMPER (RES 0.0 Ω 1210) | RK73Z2E | KOA |

Wurth : Adolf Wurth GmbH & Co. KG
 Texas Instruments : Texas Instruments, Inc
 Infineon : Infineon Technologies AG
 CEL : California Eastern Laboratories, Inc
 Fairchild : Fairchild Semiconductor International, Inc.
 Diodes : Diodes, Inc
 On Semi : ON Semiconductor
 Panasonic : Panasonic Corporation
 muRata : Murata Manufacturing Co., Ltd.
 Nippon Chemi-con : Nippon Chemi-Con Corporation
 Kemet : KEMET Electronics Corporation
 Epcos : EPCOS AG
 KOA : KOA Corporation

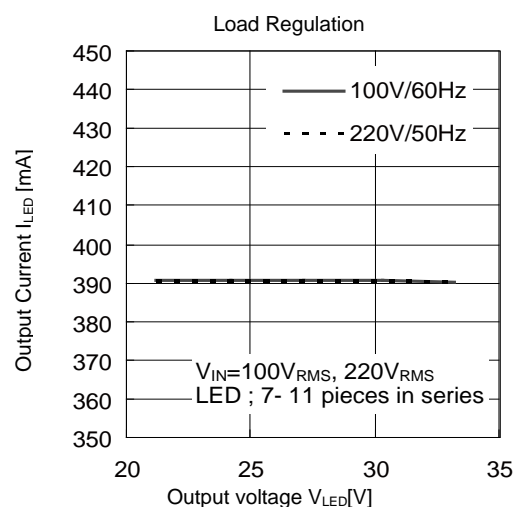
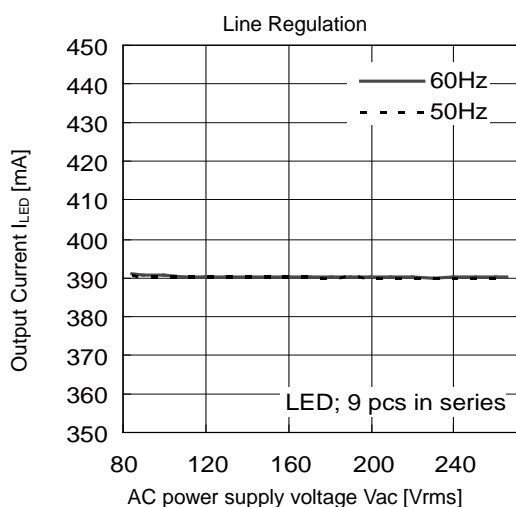
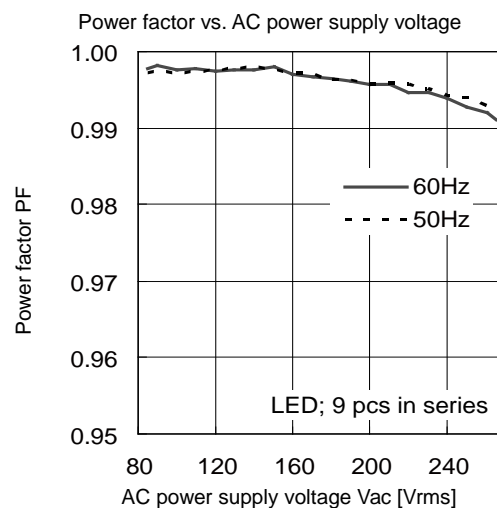
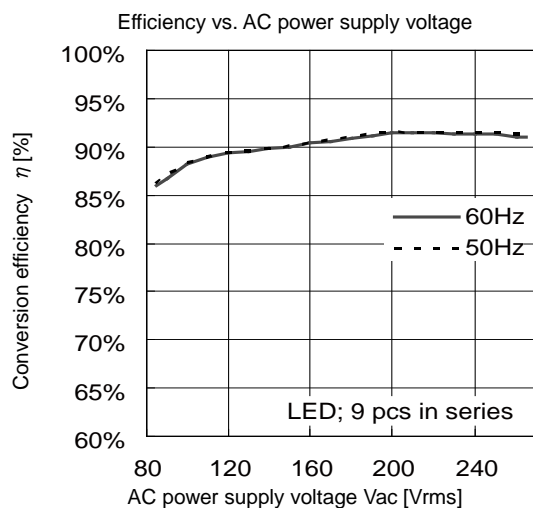
2. Non-isolation circuit

| No | Component | Description | Part No. | Vendor |
|----|-----------|---|--------------------|------------------|
| 1 | IC | Driver IC for LED Lighting, SOL8 | MB39C602 | Cypress |
| 2 | C1 | Capacitor, aluminum electrolytic, 47 μ F, 250 V, 12.5 \times 20 | EKXG251ELL470MK20S | Nippon Chemi-con |
| 3 | C2 | | | |
| 4 | C3 | Capacitor, ceramic, 10 μ F, 50 V, X7R, +/-10%, 1210 | GRM32DF51H106ZA01L | muRata |
| 5 | C4 | Capacitor, aluminum electrolytic, 100 μ F, 50 V, 8 \times 11.5 | EKMG500ELL101MHB5D | Nippon Chemi-con |
| 6 | C5, C6 | Capacitor, ceramic, 0.01 μ F, 50 V, X7R, +/-10%, 0603 | GRM188R71H103KA01D | muRata |
| 7 | C7 | Capacitor, ceramic, 0.1 μ F, 25 V, X7R, +/-10%, 0603 | GRM188R71E104KA01D | muRata |
| 8 | C8 | Capacitor, aluminum electrolytic, 100 μ F, 25 V, 6.3 \times 11 | EKMG250ELL101MF11D | Nippon Chemi-con |
| 9 | C9 | Capacitor, polyester film, 0.22 μ F, 250 V, 12 \times 5.5 \times 10.5 | ECQ-E2224KF | Panasonic |
| 10 | D1 | Diode, bridge rectifier, 0.5 A, 600 V, SO-4 | MB6S | Fairchild |
| 11 | D2 | Diode, ultra fast rectifier, 1 A, 400 V, SMA | ES1G | Fairchild |
| 12 | D3 | Diode, Schottky, 1 A, 30 V, SOD-323 | SDM100K30 | Diodes |
| 13 | D4 | Diode, ultra fast, 1 A, 200 V, SMA | CSFA103-G | On Semi |
| 14 | D5 | Diode, Zener, 18 V, 500 mW, SOD-123 | MMSZ18T1G | On Semi |
| 15 | D6, D7 | Jumper | RK73ZW2H | KOA |
| 16 | D8, D9 | | | |
| 17 | F1 | Fuse, axial, fast acting, 2.5 A, 250 V, 0.160 inch \times 0.400 inch | 026302.5MXL | Littelfuse Inc |
| 18 | L1 | Inductor, 100 μ H, 0.67 A max, 0.39 Ω max | 22R104C | muRata Ps |
| 19 | T1 | Coupling inductor, 280 μ H, 1.4 A, Na/Nm=0.6 | EI-191-03377-T | SUMIDA |
| 20 | Q1 | MOSFET, N-ch, 650 V, 7.3 A, 0.6 W, TO-220 | FDPF10N60NZ | Fairchild |
| 21 | R1 | NTC thermistor, 8.0 Ω , 1.5 A | NTPA78R0LBMB0 | muRata |
| 22 | R2, R3 | Resistor, chip, 1.00 M Ω , 1/8 W, +/-1%, 0805 | RK73H2ATTD1004F | KOA |
| 23 | R4 | Resistor, chip, 3.0 Ω , 1/8 W, +/-1%, 0805 | RK73H2ATTD3R00F | KOA |
| 24 | R5 | Resistor, chip, 5.1 Ω , 1/10 W, +/-1%, 0603 | RK73H1JTDD5R10F | KOA |
| 25 | R6 | Resistor, chip, 1.00 M Ω , 1/10 W, +/-1%, 0603 | RK73H1JTDD1004F | KOA |
| 26 | R7 | Resistor, chip, 110 k Ω , 1/10 W, +/-1%, 0603 | RK73H1JTDD1103F | KOA |
| 27 | R8 | Resistor, chip, 33 k Ω , 1/10 W, +/-1%, 0603 | RK73H1JTDD3302F | KOA |
| 28 | R9 | Resistor, chip, 91 k Ω , 1/10 W, +/-1%, 0603 | RK73H1JTDD9102F | KOA |
| 29 | R10 | Resistor, chip, 100 k Ω , 1/10 W, +/-1%, 0603 | RK73H1JTDD1003F | KOA |

Nippon Chemi-con : Nippon Chemi-Con Corporation
 muRata : Murata Manufacturing Co., Ltd.
 Panasonic : Panasonic Corporation
 Fairchild : Fairchild Semiconductor International, Inc.
 Diodes : Diodes, Inc
 On Semi : ON Semiconductor
 KOA : KOA Corporation
 muRata Ps : Murata Power Solutions, Inc
 SUMIDA : SUMIDA CORPORATION.

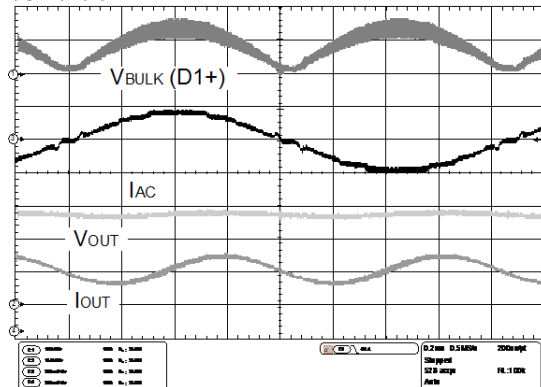
13. Reference Data

1. Isolation circuit

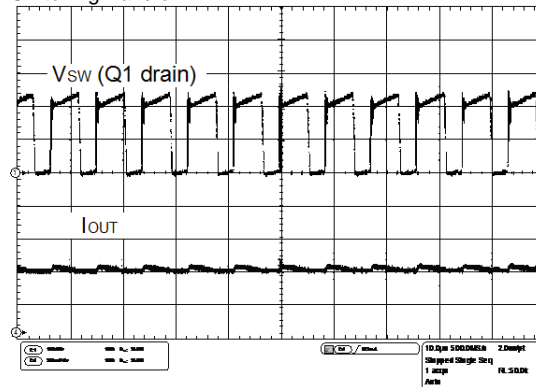


$V_{IN}=100V_{RMS}$, 60 Hz, LED; 9 pcs in series

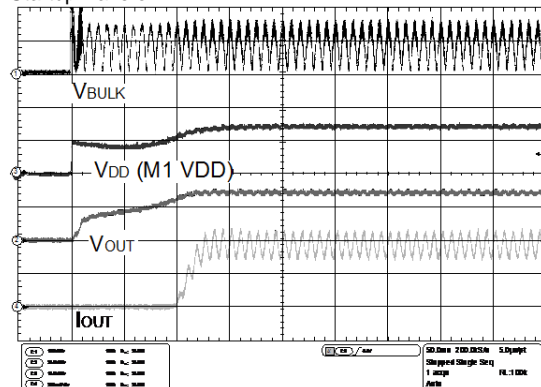
I/O waveform



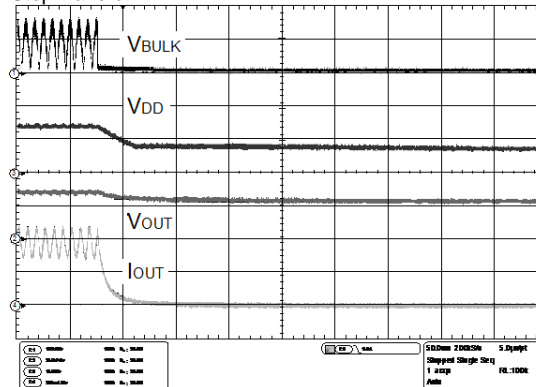
Switching waveform



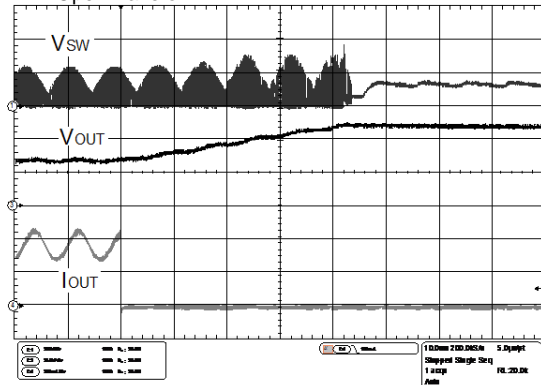
Startup waveform



Stop waveform

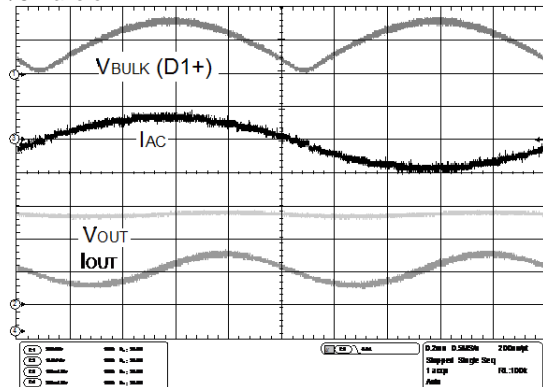


LED Open waveform

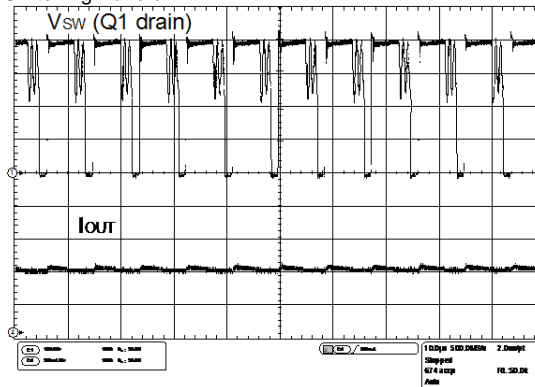


$V_{IN} = 220V_{RMS}$, 50 Hz, LED; 9 pcs in series

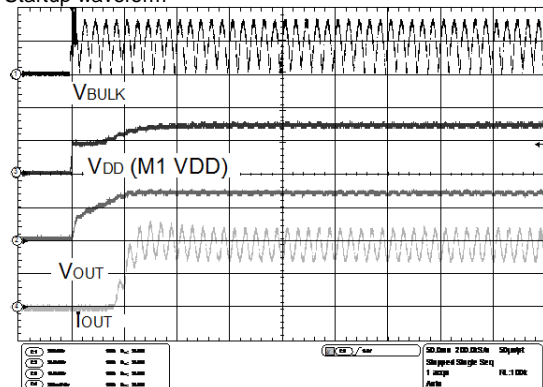
I/O waveform



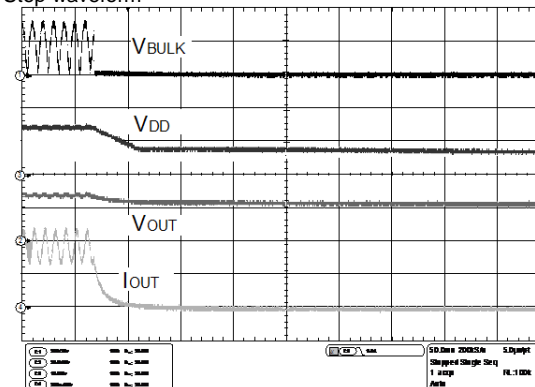
Switching waveform



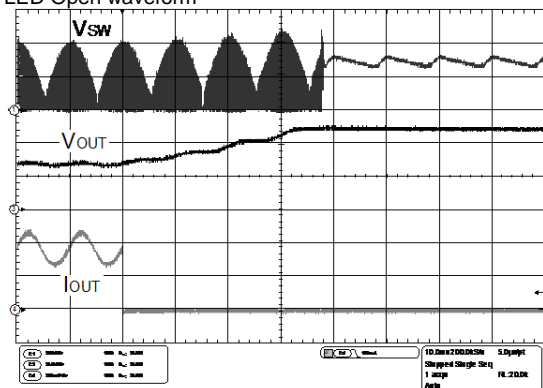
Startup waveform



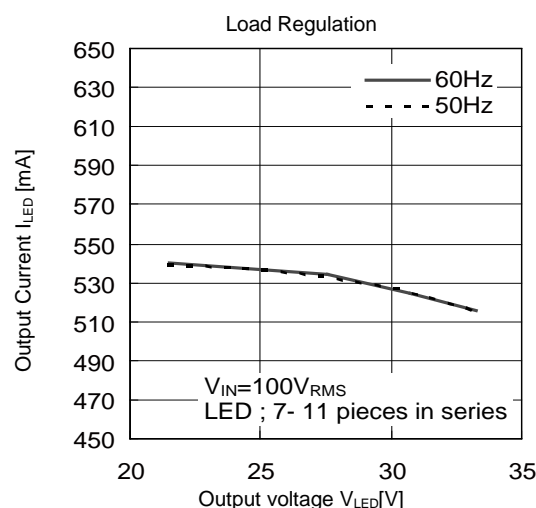
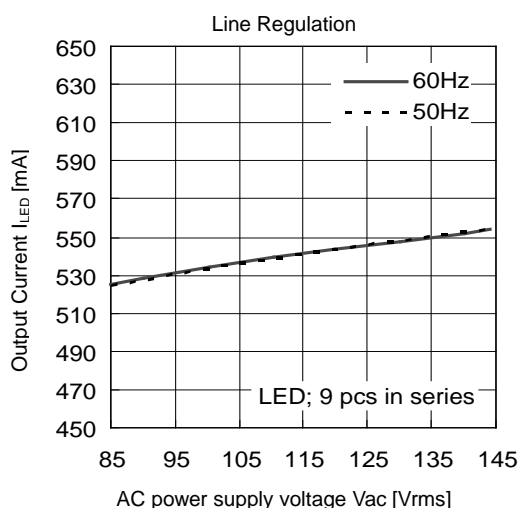
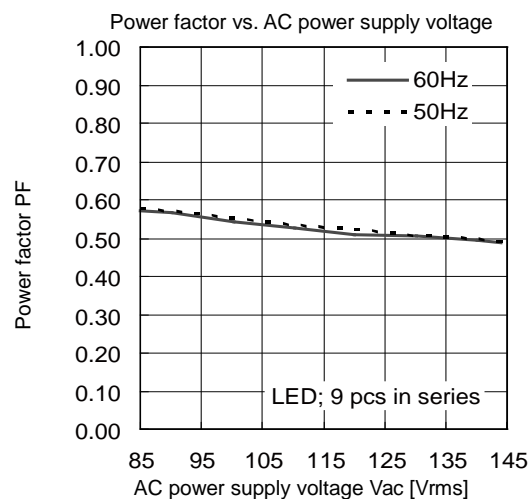
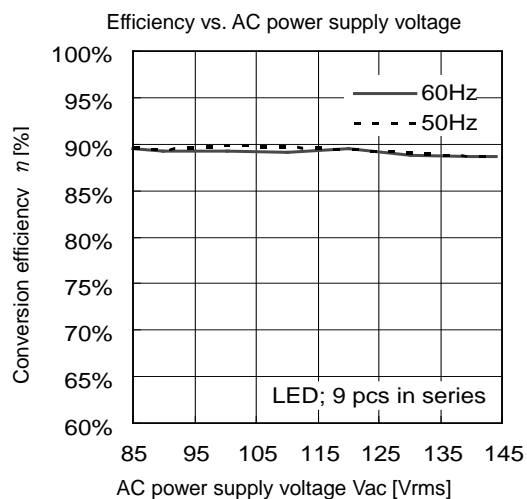
Stop waveform



LED Open waveform

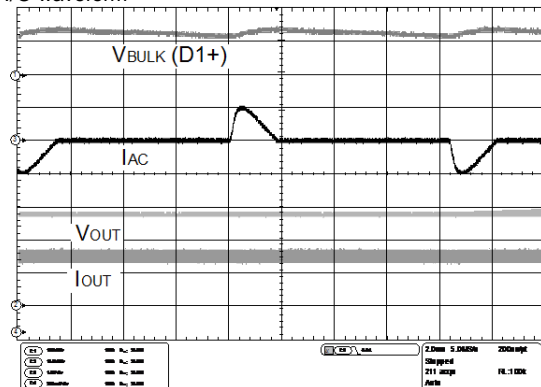


2. Non-isolation circuit

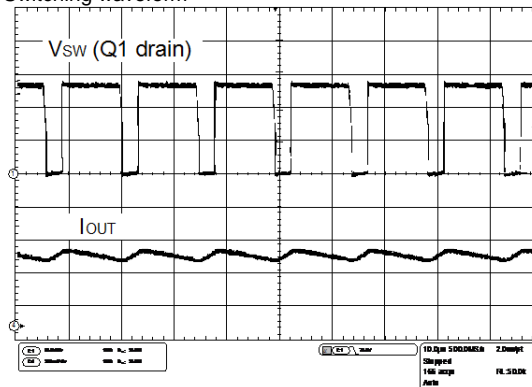


VIN=AC100V_{RMS}, fac=60 Hz, LED; 9 pieces in series

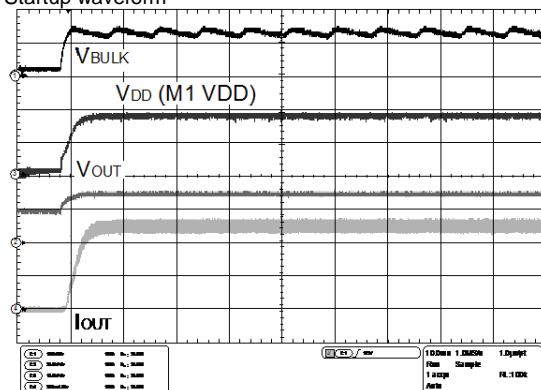
I/O waveform



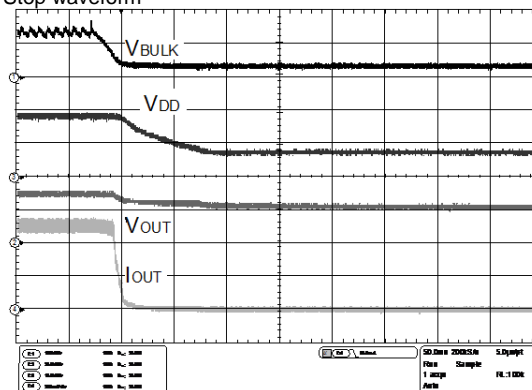
Switching waveform



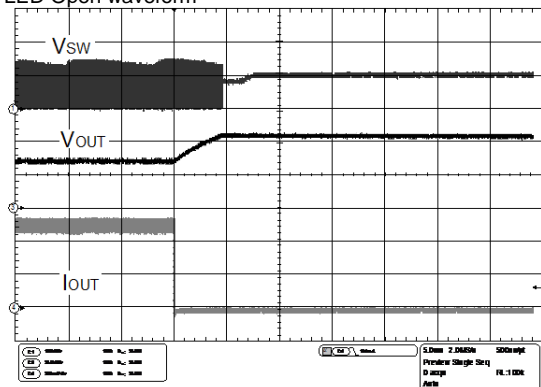
Startup waveform



Stop waveform



LED Open waveform



14. Usage Precaution

Do not configure the IC over the maximum ratings.

If the IC is used over the maximum ratings, the LSI may be permanently damaged.

It is preferable for the device to normally operate within the recommended usage conditions. Usage outside of these conditions can have an adverse effect on the reliability of the LSI.

Use the device within the recommended operating conditions.

The recommended values guarantee the normal LSI operation under the recommended operating conditions.

The electrical ratings are guaranteed when the device is used within the recommended operating conditions and under the conditions stated for each item.

Printed circuit board ground lines should be set up with consideration for common impedance.

Take appropriate measures against static electricity.

- Containers for semiconductor materials should have anti-static protection or be made of conductive material.
- After mounting, printed circuit boards should be stored and shipped in conductive bags or containers.
- Work platforms, tools, and instruments should be properly grounded.
- Working personnel should be grounded with resistance of 250 kΩ to 1 MΩ in serial between body and ground.

Do not apply negative voltages.

The use of negative voltages below - 0.3 V may make the parasitic transistor activated to the LSI, and can cause malfunctions.

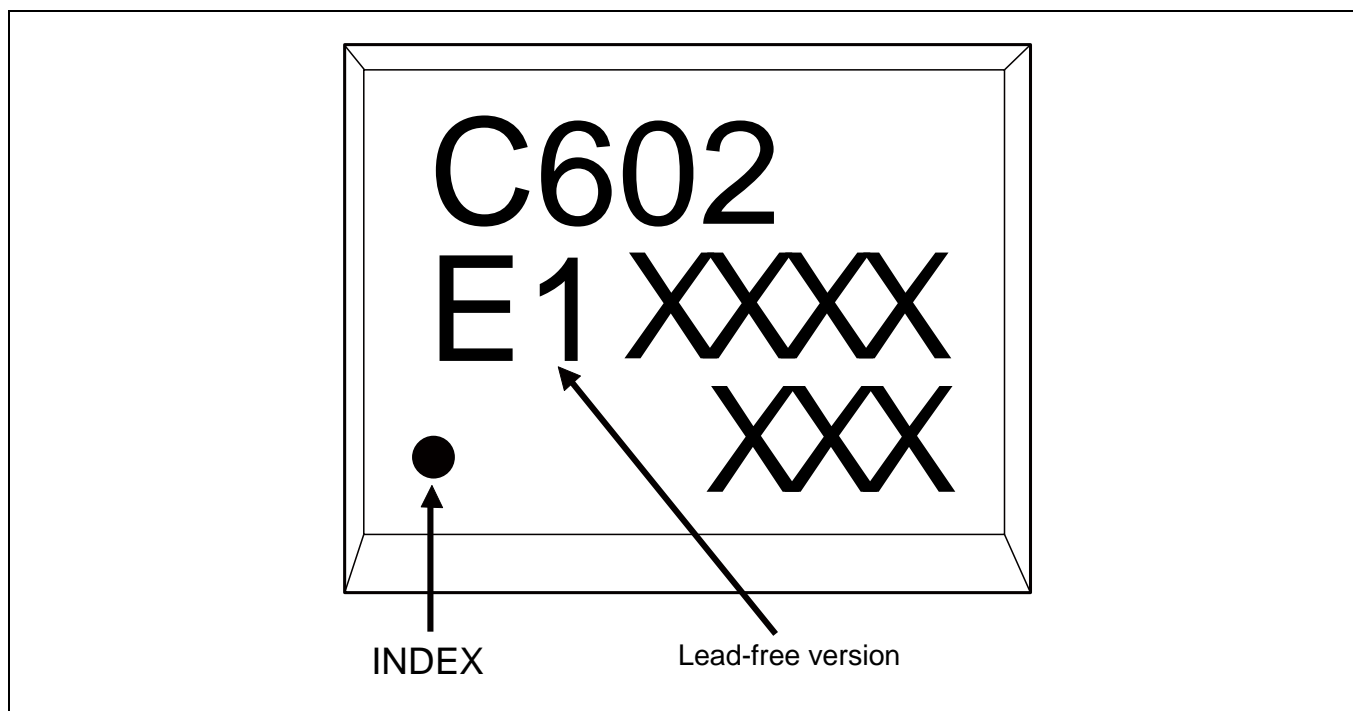
15. Ordering Information

| Part number | Package | Remarks |
|-------------|-----------------------------------|---------|
| MB39C602PNF | 8-pin plastic SOP (FPT-8P-M02) | |

16. RoHS Compliance Information Of Lead (Pb) Free Version

The LSI products of Cypress with “E1” are compliant with RoHS Directive, and have observed the standard of lead, cadmium, mercury, Hexavalent chromium, polybrominated biphenyls (PBB), and polybrominated diphenyl ethers (PBDE). A product whose part number has trailing characters “E1” is RoHS compliant.

17. Marking Format (Lead Free Version)



18. Labeling Sample (Lead free Version)

Lead-free mark
JEITA logo JEDEC logo

The part number of a lead-free product has the trailing characters "E1".

"ASSEMBLED IN CHINA" is printed on the label of a product assembled in China.

MB123456P - 789 - GE1
(3N) 1 MB123456P-789-GE1 1000
QC PASS
1,000 PCS
MB123456P - 789 - GE1
2006/03/01 ASSEMBLED IN JAPAN
MB123456P - 789 - GE1 1/1 0605 - Z01A 1000
1561190005

19.MB39C602PNF Recommended Conditions of Moisture Sensitivity Level

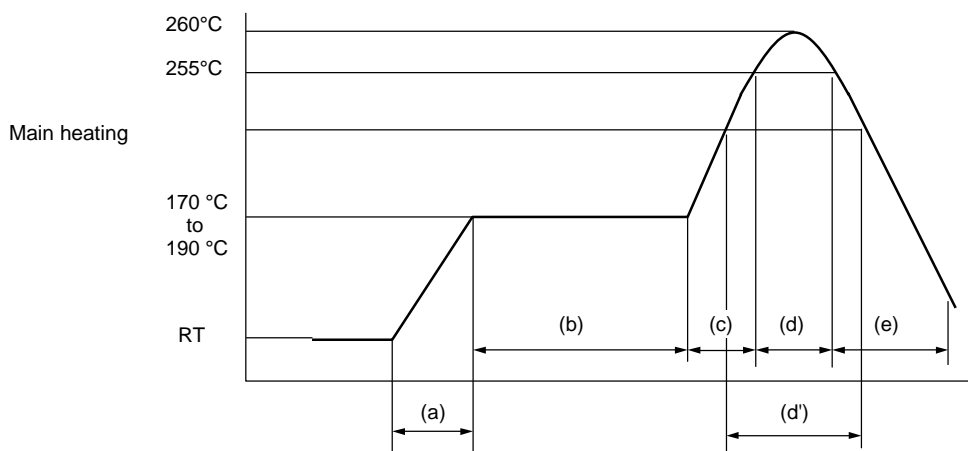
[Cypress Recommended Mounting Conditions]

Recommended Reflow Condition

| Item | Condition | |
|--------------------|--|--|
| Mounting Method | IR (infrared reflow), warm air reflow | |
| Mounting times | 2 times | |
| Storage period | Before opening | Please use it within two years after manufacture. |
| | From opening to the 2nd reflow | Less than 8 days |
| | When the storage period after opening was exceeded | Please process within 8 days after baking (125°C ±3°C, 24H+ 2H/-0H) . Baking can be performed up to two times. |
| Storage conditions | 5°C to 30°C, 70% RH or less (the lowest possible humidity) | |

[Mounting Conditions]

1. Reflow Profile



- "H" rank : 260°C Max
- (a) Temperature Increase gradient : Average 1°C/s to 4°C /s
 - (b) Preliminary heating : Temperature 170°C to 190°C, 60 s to 180 s
 - (c) Temperature Increase gradient : Average 1°C /s to 4°C /s
 - (d) Peak temperature : Temperature 260°C Max; 255°C or more, 10 s or less
 - (d') Main Heating : Temperature 230°C or more, 40 s or less
or
Temperature 225°C or more, 60 s or less
or
Temperature 220°C or more, 80 s or less
 - (e) Cooling : Natural cooling or forced cooling

Note: Temperature : the top of the package body.

2. JEDEC Condition: Moisture Sensitivity Level 3 (IPC/JEDEC J-STD-020D)

3. Recommended manual soldering (partial heating method)

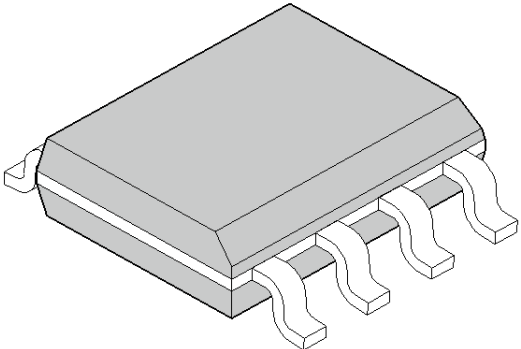
| Item | Condition | |
|---------------------|---|--|
| Storage period | Before opening | Within two years after manufacture |
| | Between opening and mounting | Within two years after manufacture (No need to control moisture during the storage period because of the partial heating method.) |
| Storage conditions | 5°C to 30°C, 70% RH or less (the lowest possible humidity) | |
| Mounting conditions | Temperature at the tip of a soldering iron: 400°C Max Time: Five seconds or below per pin ^[1] | |

[1]: Make sure that the tip of a soldering iron does not come in contact with the package body.

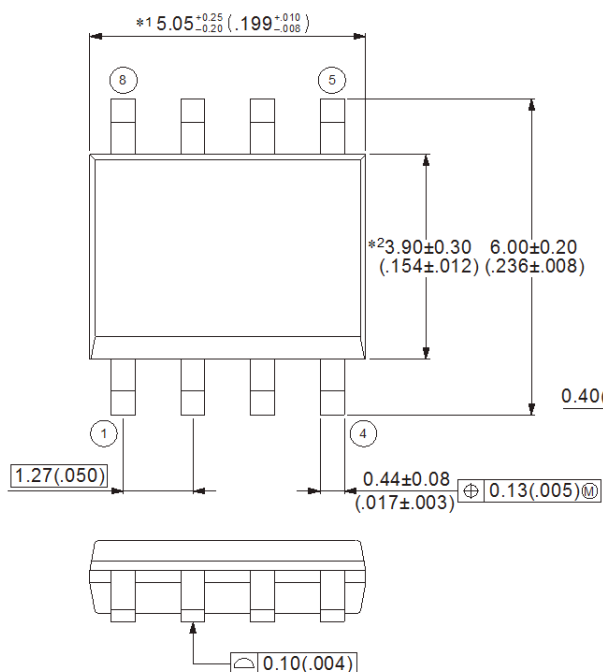
4. Recommended dip soldering

| Item | Condition | |
|--------------------|--|--|
| Mounting times | 1 time | |
| Storage period | Before opening | Please use it within two years after manufacture. |
| | From opening and mounting | Less than 14 days |
| | When the storage period after opening was exceeded | Please process within 14 days after baking (125°C ±3°C, 24H+ 2H/—0H) . Baking can be performed up to two times. |
| Storage conditions | 5°C to 30°C, 70% RH or less (the lowest possible humidity) | |
| Mounting condition | Temperature at soldering tub: 260°C Max Time: Five seconds or below | |

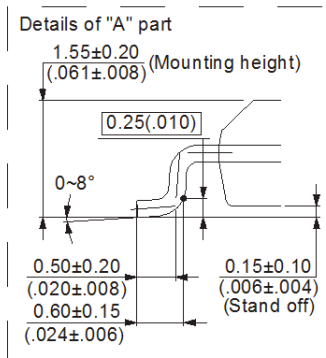
20. Package Dimensions

| | | |
|---|---------------------------------------|-------------------------|
| <p>8-pin plastic SOP</p>  <p>(FPT-8P-M02)</p> | Lead pitch | 1.27 mm |
| | Package width × package length | 3.9 mm × 5.05 mm |
| | Lead shape | Gullwing |
| | Sealing method | Plastic mold |
| | Mounting height | 1.75 mm MAX |
| | Weight | 0.06 g |
| | | |

**8-pin plastic SOP
(FPT-8P-M02)**



Note 1) *1 : These dimensions include resin protrusion.
 Note 2) *2 : These dimensions do not include resin protrusion.
 Note 3) Pins width and pins thickness include plating thickness.
 Note 4) Pins width do not include tie bar cutting remainder.



21. Major Changes

Spanion Publication Number: MB39C602_DS405-00010

| Page | Section | Change Results |
|---------------------------------|----------------------------------|--|
| Revision 1.0 [December, 2012] | | |
| - | - | Initial release |
| Revision 2.0 [July, 2013] | | |
| 5 | RECOMMENDED OPERATING CONDITIONS | Revised the minimam value of symbol "ROTC". 25 → 10 |
| 8, 9 | TYPICAL CHARACTERISTICS | Added "TYPICAL CHARACTERISTICS". |
| 21 to 25 | EXAMPLE APPLICATION CIRCUIT | Added "EXAMPLE APPLICATION CIRCUIT". |
| 26 to 30 | REFERENCE DATA | Added "REFERENCE DATA". |
| Revision 2.1 [January 31, 2014] | | |
| - | - | Company name and layout design change |

NOTE: Please see "Document History" about later revised information.

Document History

Document Title: MB39C602 High Power Factor LED Driver IC for LED Lighting

Document Number: 002-08397

| Revision | ECN | Orig. of Change | Submission Date | Description of Change |
|----------|---------|-----------------|-----------------|--|
| ** | — | TAOA | 01/31/2014 | Migrated to Cypress and assigned document number 002-08397. No change to document contents or format. |
| *A | 5211073 | TAOA | 04/13/2016 | Updated to Cypress format. |

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Technical Support

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