# INTEGRATED PHOTO FLASH CHARGER AND IGBT DRIVER

## FEATURES

- **Wide Input Voltage**
  - **VBAT = 1.4 V to 12 V**
  - **VCC = 2.5 V to 5.5 V**
- **Integrated 50-V Power Switch With Lower $R_{ON}$**
- **Programmable Peak Current at Primary Side From 0.5 A to 1.5 A**
- **Optimized Switch ON/OFF Control for Fast Charging**
- **Charge Complete Detection at Primary Side With High Accuracy**
- **Integrated IGBT Driver**
- **2-mm × 3-mm, 12-Pin WSON Package**
- **Protection**
  - **Overcurrent Protection (OCP)**
  - **Thermal Shutdown (TSD)**

## APPLICATIONS

- **Digital Still Cameras**
- **Optical Film Cameras**
- **Digital Video Camcorders**
- **Cell Phones**

## DESCRIPTION/ORDERING INFORMATION

The TPS65573 offers a complete solution for a charging photo flash capacitor and flashing xenon tube with insulated gate bipolar transfer (IGBT) driver. This device has an integrated voltage reference, power (SW), comparators for peak current detection/power SW turnon detection/charge complete detection, IGBT driver and control logics for charging applications/driving IGBT applications.

Compared with discrete solutions, this device reduces the component count, shrinks the total solution size, and erases the difficulty of design for xenon tube application.

Additional advantages are a fast charging time and high efficiency since this device has an optimized pulse width modulation (PWM) control algorithm for photo flash charging. Also this device has high accuracy for peak current detection and for charge completion detection. The distribution of charging time is smaller.

Other provisions of the device include sensing the output voltage at the primary side, programmable peak current at the primary side, protection features (thermal shutdown and overcurrent), an output pin for charge completion detection, input pins for charge enable, flash acceptable, and flash on.

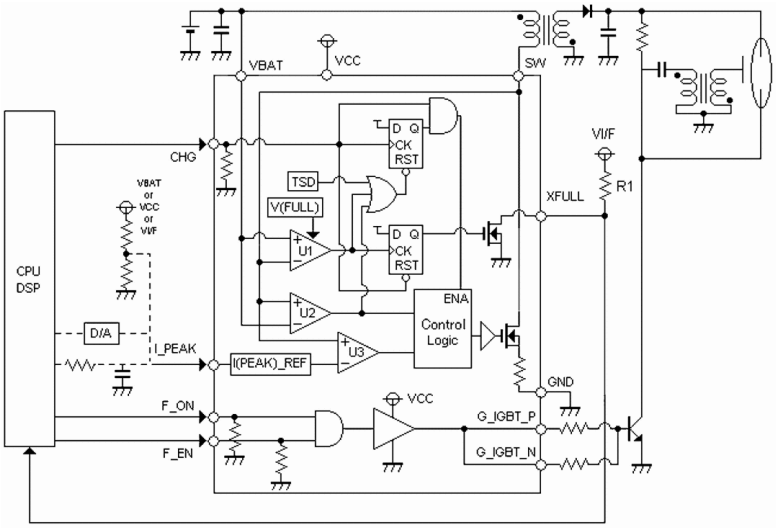



**Figure 1. Application Circuit**

These devices have limited built-in ESD protection. The leads should be shorted together or the device placed in conductive foam during storage or handling to prevent electrostatic damage to the MOS gates.

## ORDERING INFORMATION

| $T_A$ | PACKAGE(1)(2) | ORDERABLE PART NUMBER | TOP-SIDE MARKING | TRANSPORT MEDIA, QUANTITY |
|---|---|---|---|---|
| –35°C to 85°C | WSON | TPS65573DSST | CVR | Tape and Reel, 250 |
| | | TPS65573DSSR | | Tape and Reel, 3000 |

(1) Package drawings, standard packing quantities, thermal data, symbolization, and PCB design guidelines are available at www.ti.com/sc/package.
(2) For the most current package and ordering information, see the Package Option Addendum at the end of this document, or see the TI website at www.ti.com.

## ABSOLUTE MAXIMUM RATINGS(1)

over operating free-air temperature range (unless otherwise noted)

| | | | | UNIT |
|---|---|---|---|---|
| | Supply voltage range | VCC | –0.6 to 6 | V |
| | | VBAT | –0.6 to 13 | |
| $V_{SW}$ | Switch terminal voltage range | | –0.6 to 50 | V |
| $I_{SW}$ | Switch current between SW and GND | | 2 | A |
| $V_I$ | Input voltage range | CHG, I_PEAK, and F_ON | –0.3 to $V_{CC}$ | V |
| $T_{stg}$ | Storage temperature range | | –40 to 150 | °C |
| $T_J$ | Maximum junction temperature | | 125 | °C |

(1) Stresses beyond those listed under "absolute maximum ratings" may cause permanent damage to the device. These are stress ratings only, and functional operation of the device at these or any other conditions beyond those indicated under "recommended operating conditions" is not implied. Exposure to absolute-maximum-rated conditions for extended periods may affect device reliability.

## RECOMMENDED OPERATING CONDITIONS

| | | | MIN | MAX | UNIT |
|---|---|---|---|---|---|
| | Supply voltage | VCC | 2.5 | 5.5 | V |
| | | VBAT | 1.4 | 12 | |
| $V_{SW}$ | Switch terminal voltage | | –0.3 | 45 | V |
| $I_{SW}$ | Switch current between SW and GND | | | 1.5 | A |
| | Operating free-air temperature | | –35 | 85 | °C |
| $V_{IH}$ | High-level digital input voltage at CHG and F_ON | | 1.5 | | V |
| $V_{IL}$ | Low-level digital input voltage at CHG and F_ON | | | 0.5 | V |

## DISSIPATION RATINGS

| PACKAGE | $R_{\theta JA}$(1) | POWER RATINGS $T_A$ < 25°C | POWER RATINGS RATE $T_A$ = 85°C |
|---|---|---|---|
| DFN | 54.5°C/W | 1.84 W | 0.74 W |

(1) The thermal resistance, $R_{\theta JA}$, is based on a soldered PowerPAD™ package on a 2S2P JEDEC board using thermal vias.

## ELECTRICAL CHARACTERISTICS

$T_A$ = 25°C, VBAT = 4.2 V, VCC = 3 V, $V_{(SW)}$ = 4.2 V (unless otherwise noted)

| PARAMETER | | TEST CONDITIONS | MIN | TYP | MAX | UNIT |
|---|---|---|---|---|---|---|
| $I_{CC1}$ | Supply current from VBAT | $V_{(CHG)}$ = VCC, $V_{(F\_ON)}$ = GND, $V_{(F\_EN)}$= GND, XFULL = Hi-Z | | 140 | 200 | µA |
| $I_{CC2}$ | Supply current from VCC | $V_{(CHG)}$ = VCC, $V_{(F\_ON)}$ = GND, $V_{(F\_EN)}$ = GND, XFULL = Hi-Z | | 2 | 3 | mA |
| $I_{CC3}$ | Supply current from VCC and VBAT | $V_{(CHG)}$ = GND, $V_{(F\_ON)}$ = GND, $V_{(F\_EN)}$ = GND | | | 1 | µA |
| $I_{LKG1\_SW}$ | Leakage current at SW | $V_{(SW)}$ = 4.2 V | | | 2 | µA |
| $I_{LKG2\_SW}$ | Leakage current at SW | $V_{(SW)}$ = 45 V | | | 600 | µA |
| $I_{sink}$ | Sink current at I_PEAK | VCC = $V_{(I\_PEAK)}$ = 3 V | | | 0.1 | µA |
| $I_{PEAK1}$ | Lower point of Peak current detection | $V_{(I\_PEAK)}$= 0.1V | 0.38 | 0.58 | 0.78 | A |
| $I_{PEAK2}$ | Middle point of Peak current detection | $V_{(I\_PEAK)}$ = 0.65 V | 0.84 | 1.04 | 1.24 | A |
| $I_{PEAK3}$ | Upper point of Peak current detection | $V_{(I\_PEAK)}$ = 1.5 V | 1.30 | 1.50 | 1.70 | A |
| $R_{ON\_XFULL}$ | ON resistance between XFULL and GND | $I_{(XFULL)}$ = 1 mA | | 1.5 | 3 | kΩ |
| $R_{ON\_SW}$ | ON resistance between SW and GND | $I_{(SW)}$ = 1 A, VCC = 3 V | | 0.4 | 0.7 | Ω |
| $R_{G\_IGBT\_N}$ | G_IGBT_N ON resistance | $V_{(G\_IGBT\_N)}$ = GND | 3 | 5 | 7.5 | Ω |
| $R_{G\_IGBT\_P}$ | G_IGBT_P ON resistance | $V_{(G\_IGBT\_P)}$ = 3 V | 3 | 5 | 7.5 | Ω |
| $R_{INPD}$ | Pulldown resistance of CHG, F_ON and F_EN | $V_{(CHG)}$, $V_{(F\_ON)}$, $V_{(F\_EN)}$ = VCC | | 100 | | kΩ |
| $T_{SD}$ (1) | Thermal shutdown detection temperature | | 140 | 150 | 160 | °C |
| $V_{FULL}$ | Charge completion detection voltage at SW | | VBAT + 28.6 | VBAT + 29.0 | VBAT + 29.4 | V |
| $V_{ZERO}$ | Zero current detection at SW | | VBAT + 10m | VBAT + 25m | VBAT + 40m | V |
| $V_{OCP}$ | Over current protection trigger voltage at SW | | VBAT – 150m | VBAT – 100m | VBAT – 50m | V |

(1) Specified by design

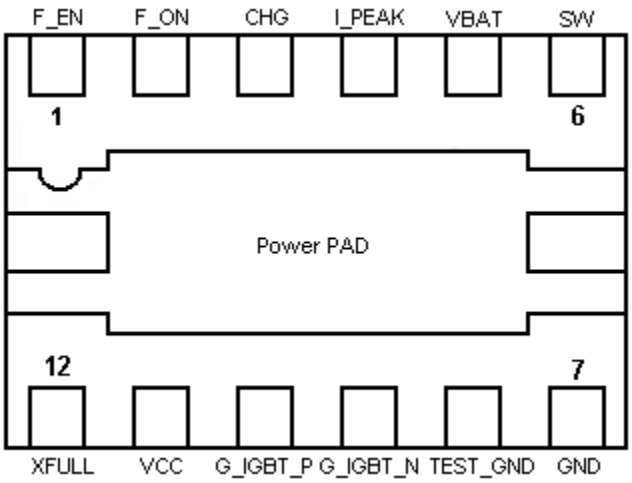
## SWITCHING CHARACTERISTICS

$T_A$ = 25°C, VBAT = 4.2 V, VCC = 3 V, $V_{SW}$ = 4.2 V (unless otherwise noted)

| PARAMETER | | TEST CONDITIONS | MIN | TYP | MAX | UNIT |
|---|---|---|---|---|---|---|
| $t_{PD}$ (1) | Propagation delay | G_IGBT turns high/low after F_ON turns high/low | | 25 | | ns |
| | | SW OFF after $I_{SW}$ exceeds the threshold defined by I_PEAK | | 150 | | |
| | | XFULL turns Low after $V_{SW}$ exceeds $V_{FULL}$ | | 200 | | |
| | | SW ON after CHG turns high | | 50 | 150 | µs |

(1) Specified by design

**PIN ASSIGNMENT**
**(BOTTOM VIEW)**




## TERMINAL FUNCTIONS

| TERMINAL | | I/O | DESCRIPTION |
|---|---|---|---|
| NO. | NAME | | |
| 1 | F_EN | I | Flash Acceptable input. High level is acceptable to Xenon Flash on with F_ON pin. Low level is to force Disable of Xenon Flash on in spite of F_ON being High. |
| 2 | F_ON | I | Flash enable/disable. High level is xenon flash on with F_EN being high. Low level is xenon flash off even if F_EN is high. |
| 3 | CHG | I | Charge enable/disable input. Drive CHG high to start charging the output capacitor. Drive CHG low to terminate charging. |
| 4 | I_PEAK | I | Primary-side peak current control input. The voltage at I_PEAK sets the peak current into SW. See the *Programming Peak Current* section for details on selecting $V_{I\_PEAK}$. |
| 5 | VBAT | I | Battery voltage monitor input for detecting OFF timing of power MOSFET. Connect VBAT pin to an input voltage from battery. The arrowable range is from 1.4 V to 12 V. Bypass VBAT to GND with a 10 µF ceramic capacitor as close to the IC as possible. |
| 6 | SW | O | Primary-side power MOSFET switch. Connect SW to the switched side of the transformer. |
| 7 | GND | – | Ground for power and IC internal cicruits. Connect to the ground plane. |
| 8 | TEST_GND | – | Used by TI, should be connected to GND and ground plane |
| 9 | G_IGBT_N | O | IGBT gate driver output for turning off G_IGBT swings from VCC to GND to drive external IGBT devices. The external resistor should be needed at outside. The value depends on the characteristics of IGBT. |
| 10 | G_IGBT_P | O | IGBT gate driver output for turning on G_IGBT swings from GND to VCC to drive external IGBT devices. The external resistor should be needed at outside. The value depends on the characteristics of IGBT. |
| 11 | VCC | I | Power supply. VCC is the gate drive supply and IC supply. The allowable range is from 2.7 V to 5.5 V. Bypass VCC to GND with a 1-µF ceramic capacitor as close to the IC as possible. |
| 12 | XFULL | O | Charge completion indicator output. XFULL is an open-drain output that pulls low once the output is fully charged. XFULL is high impedance during charging and all fault conditions. The recovery condition from Low to High is to turn Low at CHG pin only. |

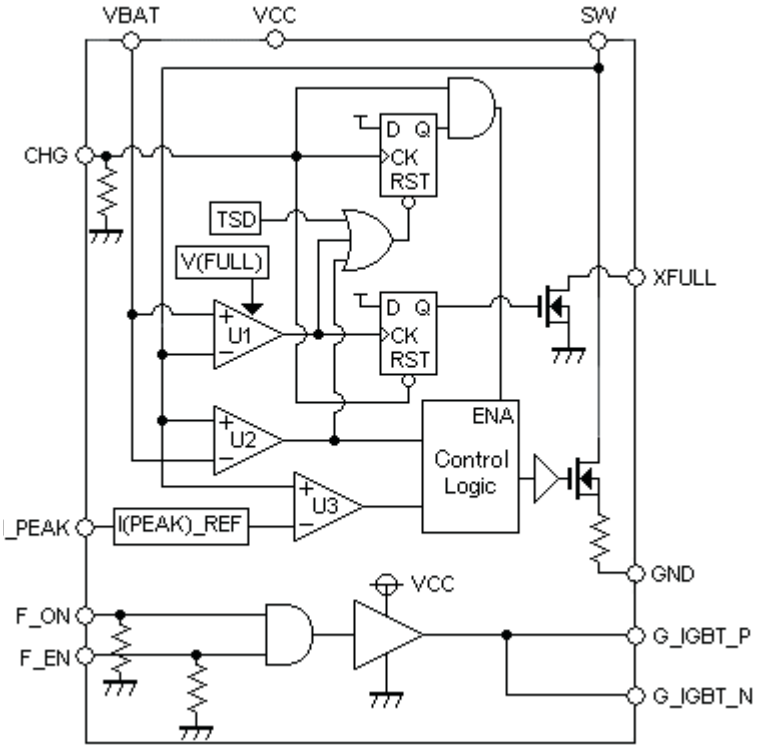



**Figure 2. Block Diagram**

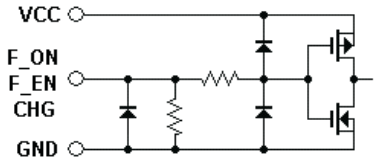
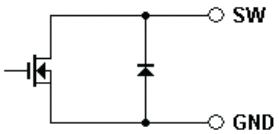
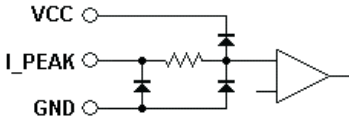
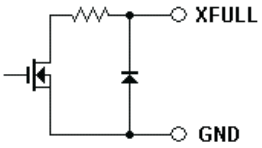
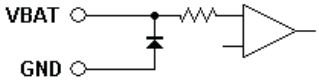
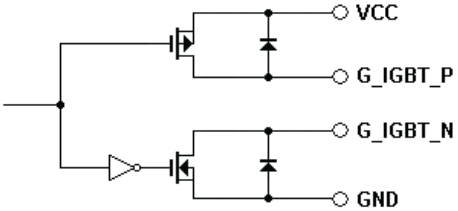
| CHG, F_ON, F_EN | SW |
|---|---|
|  |  |
| **I_PEAK** | **XFULL** |
|  |  |
| **VBAT** | **G_IGBT_P, G_IGBT_N** |
|  |  |



**Figure 3. I/O Equivalent Circuit**

## PRINCIPLES OF OPERATION

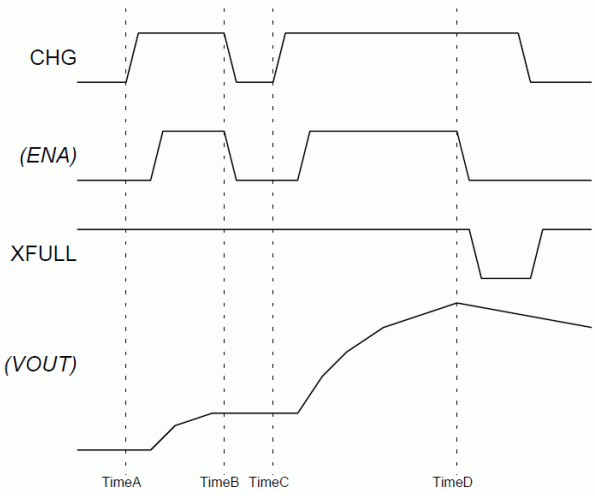



**Figure 4. Charging Sequence Chart**

### Start/Stop Charging

The TPS65573 has an enable/disable pin for charging (CHG). The only way to start charging is to input a high-level signal into CHG (see A and C in Figure 2). This high level is latched by internal D-FF shown in Figure 2. The internal enable (ENA) signal goes up with some delay, which is specified as SW ON after CHG↑ in Switching Characteristics. This is to avoid the wrong operation with a pulsed noise at CHG.

To stop charging, there are three trigger events:

- Forced stop by inputting a low level at CHG (see B in Figure 4)
- Automatic stop by detecting a full charge. VOUT reaches the target value (see D in Figure 4).
- Protected stop by detecting an overcurrent protection (OCP) on the SW pin

When the host inputs the high-level signal into CHG, the voltage of VCC and VBAT must meet the recommended range; VBAT is from 1.4 V to12 V, VCC is from 2.5 V to 5.5 V. It is acceptable to start recharging after a forced stop controlled by CHG (see C in Figure 4).

### Charging Status Indication

When the charging operation is complete, the TPS65573 drives the charge completion indicator pin, XFULL, to a low level. A controller can detect the status of the device as a logic signal when it is connected through a pullup resistor (R1) (see Figure 1). The only way to reset the indication at XFULL is to input a low level into CHG (see Figure 4).

The XFULL output enables the controller to find the device-protected situation. If overcurrent protection (OCP) occurs, XFULL never goes to a low level when CHG is at a high level. Therefore, the controller detects OCP by measuring the time from turning CHG to a high level to turning XFULL to a low level. If the duration is longer than the maximum designed charge time, OCP occurs.

## Charging Control

Figure 5 shows a timing diagram at beginning/ending. The TPS65573 provides three comparators to control the charging operation. U1 is the $V_{FULL}$ comparator to detect the charge completion, U2 is the $V_{ZERO}$ comparator to detect the turn-on time of the power SW, and U3 is the $I_{PEAK}$ comparator to detect the turn-off time of the power SW.

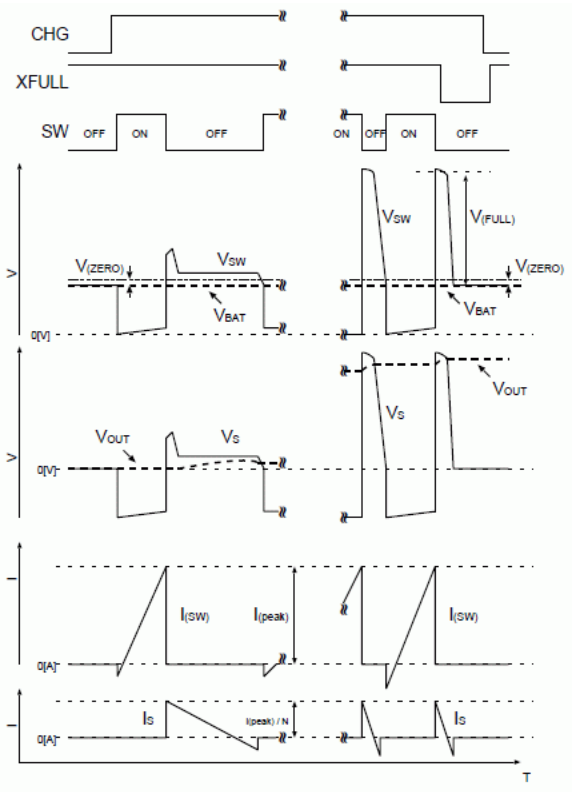



**Figure 5. Beginning/Ending Timing**

While the power SW is ON, the $I_{PEAK}$ comparator (U3) monitors current flow through the power SW from SW to GND. When the current at SW ($I_{SW}$) exceeds the threshold defined by the voltage of the I_PEAK pin ($I_{PEAK}$), the power SW turns OFF.

After the power SW turns OFF, the spike voltage occurs immediately because of leakage inductance at the primary side. It might cause the power SW to break. To avoid this, the leakage inductance should be reduced as much as possible.

When the power SW is OFF, the magnetic energy in the transformer starts discharging from the primary side to the secondary side. During this discharge, the $V_{ZERO}$ comparator (U2) monitors the kickback voltage at the primary side to compare it with the VBAT voltage. The kickback voltage increases rapidly until the diode placed at secondary side turns ON. The diode turns ON when the voltage of secondary side of the transformer reaches more than the voltage of the output capacitor. After the diode turns ON, the kickback voltage is almost stable until the magnetic energy at the primary side discharges completely.

After the discharge stops, the small amount of energy left in the transformer is released via parasitic paths, and the kickback voltage reaches almost zero voltage. During this period, U2 makes the power SW turn ON when ($V_{SW}$ – VBAT) drops from $V_{ZERO}$.

The $V_{FULL}$ comparator (U1) also monitors the kickback voltage. When $V_{SW}$ – VBAT exceeds $V_{FULL}$, the TPS65573 stops the charging operation. After detection, XFULL goes to low level to indicate charge completion. After charge completion, the TPS65573 immediately goes into disable mode with the internal ENA automatically turning to a low level. The purpose is to save the consumption power.

In Figure 5, ON time is almost the same period in every switch cycle. But the current at SW always starts from negative value because of the Trr of the diode. Because of this, ON time depends on Trr. ON time is calculated by Equation 1.

$$T_{ON(n)} = L_p \frac{I_{PEAK}}{VBAT} + Trr(n) \quad (1)$$

Where:

$T_{ON(n)}$ = ON time at n cycle switching

Lp = Inductance of primary side

$I_{PEAK}$ = Peak current at primary side

VBAT = Battery voltage

Trr(n) = Reverse recovery time at n cycle switching

OFF time is dependant on output voltage. As the output voltage gets higher, OFF time gets shorter (see Equation 2).

$$T_{OFF(n)} = N \times L \frac{I_{PEAK}}{V_{OUT(n)}} \quad (2)$$

Where:

$T_{OFF(n)}$ = OFF time at n cycle switching

N = Turn ration of transformer

$V_{OUT(n)}$ = Output voltage at n cycle switching

## Programming Peak Current

The TPS65573 provides a method to program the peak primary current with a voltage applied to the I_PEAK pin. Figure 6 shows how to program $I_{PEAK}$.

Figure 6 shows the relationship between I_PEAK pin voltage and a peak current at the primary side. This function has the analog slope controlled by I_PEAK. The maximum voltage to control peak current at the primary side is around 1.2 V.

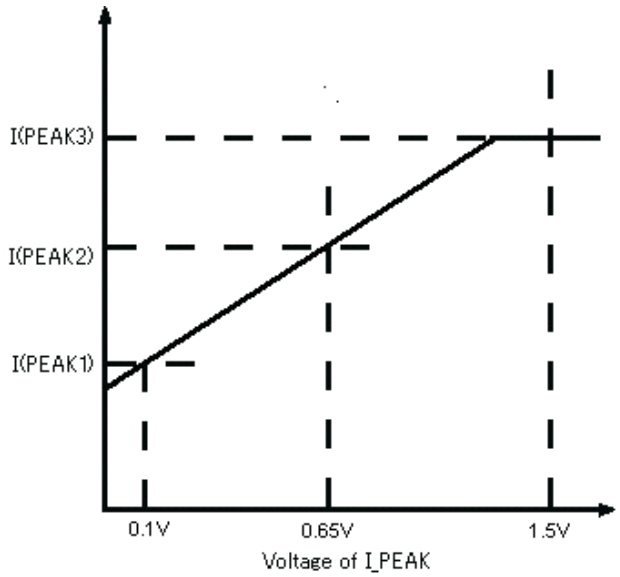



**Figure 6. I_PEAK Pin Voltage vs Peak Current at Primary Side**

Typical usages of this function are:

- Setting the peak charging currents based on the battery voltage. The easiest way is to connect a resistive divider with battery voltage. This saves battery life.
- Reducing peak current at the primary side when the system powers a zoom-lens motor. This avoids inadvertent shutdowns due to a large current from the battery.

In Figure 1, three optional connections to I_PEAK are shown:

1. Use the controller to input PWM signal with RC filter.
2. Use a digital-to-analog converter (DAC).
3. Use a resistive divider to input a fixed value into I_PEAK.

Methods 1 and 2 make it possible to delicately control peak current at the primary side. For example, set higher current during initial charging, but set lower current just before complete charging. This effectively saves the battery life.

## IGBT Driver Control

The TPS65573 integrates an IGBT driver for flashing the xenon tube. After charge completion, the xenon tube allows turnon with the IGBT driver. If the earlier flashing is needed before charge completion, the confirmation of the lowest allowable flashing voltage to apply to the xenon tube is required.

G_IGBT should be connected to the gate of IGBT as close as possible to avoid the misoperation of flashing or breaking the gate of IGBT. The output voltage of G_IGBT voltage depends on IGBT_VCC. The rise time and fall time of G_IGBT are almost the same because the TPS65573 does not include a pullup/pulldown resistor for the IGBT driver. The rise time and fall time should be met with the value specified in the data sheet of the IGBT to avoid breaking the IGBT.

The IGBT drive hasone logic input, named F_ON. To turn on the xenon tube, high-level signal should be inputted into both F_ON.

### Protection

The TPS65573 provides two protection mechanisms; thermal shutdown and overcurrent protection.

#### *Thermal Shutdown (TSD)*

Once the TPS65573 die temperature reaches a specific temperature, the operation is immediately latched off. To recover the operation, the TPS65573 die temperature should be lower than a specific temperature and forced to a low level at CHG if protection is needed.

#### *Overcurrent Protection (OCP)*

The TPS65573 has OCP at the SW pin. The TPS65573 is latched off if the SW pin is dropped to compare VBAT pin voltage during the switch ON time. The threshold is specified in Overcurrent Protection Trigger Voltage at SW in Electrical Characteristics. To recover the operation, the CHG level is forced to a low level after protection occurs and peak current is less than threshold.

## PACKAGING INFORMATION

| Orderable Device | Status (1) | Package Type | Package Drawing | Pins | Package Qty | Eco Plan (2) | Lead/Ball Finish (6) | MSL Peak Temp (3) | Op Temp (°C) | Device Marking (4/5) | Samples |
|---|---|---|---|---|---|---|---|---|---|---|---|
| TPS65573DSSR | NRND | WSON | DSS | 12 | | TBD | Call TI | Call TI | -35 to 85 | CVR | |
| TPS65573DSST | NRND | WSON | DSS | 12 | | TBD | Call TI | Call TI | -35 to 85 | CVR | |

**(1)** The marketing status values are defined as follows:
**ACTIVE:** Product device recommended for new designs.
**LIFEBUY:** TI has announced that the device will be discontinued, and a lifetime-buy period is in effect.
**NRND:** Not recommended for new designs. Device is in production to support existing customers, but TI does not recommend using this part in a new design.
**PREVIEW:** Device has been announced but is not in production. Samples may or may not be available.
**OBSOLETE:** TI has discontinued the production of the device.

**(2)** **RoHS:** TI defines "RoHS" to mean semiconductor products that are compliant with the current EU RoHS requirements for all 10 RoHS substances, including the requirement that RoHS substance do not exceed 0.1% by weight in homogeneous materials. Where designed to be soldered at high temperatures, "RoHS" products are suitable for use in specified lead-free processes. TI may reference these types of products as "Pb-Free".
**RoHS Exempt:** TI defines "RoHS Exempt" to mean products that contain lead but are compliant with EU RoHS pursuant to a specific EU RoHS exemption.
**Green:** TI defines "Green" to mean the content of Chlorine (Cl) and Bromine (Br) based flame retardants meet JS709B low halogen requirements of <=1000ppm threshold. Antimony trioxide based flame retardants must also meet the <=1000ppm threshold requirement.

**(3)** MSL, Peak Temp. - The Moisture Sensitivity Level rating according to the JEDEC industry standard classifications, and peak solder temperature.

**(4)** There may be additional marking, which relates to the logo, the lot trace code information, or the environmental category on the device.

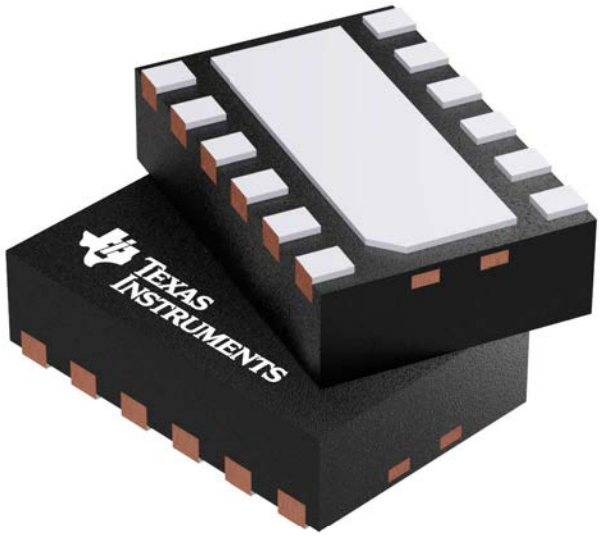
**(5)** Multiple Device Markings will be inside parentheses. Only one Device Marking contained in parentheses and separated by a "~" will appear on a device. If a line is indented then it is a continuation of the previous line and the two combined represent the entire Device Marking for that device.

**(6)** Lead/Ball Finish - Orderable Devices may have multiple material finish options. Finish options are separated by a vertical ruled line. Lead/Ball Finish values may wrap to two lines if the finish value exceeds the maximum column width.

# GENERIC PACKAGE VIEW

## DSS 12 WSON - 0.8 mm max height

PLASTIC SMALL OUTLINE - NO LEAD




Images above are just a representation of the package family, actual package may vary.
Refer to the product data sheet for package details.

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