

## 5.5 V Low Loss Power Distribution Switch

### ■ Features

- Input voltage: 2.7 V to 5.5 V
- Typical 57 mΩ on-resistance
- Five different current limit versions
- Undervoltage lockout
- Overcurrent protection, short circuit protection and over temperature protection
- Fault time 8 ms (typ) with blanking
- Reverse blocking (no body diode)
- No reverse current when power ON or power OFF
- Enable polarity: active high or active low
- Quick output discharge
  - DIO70040H: available, EN high
  - DIO70040NH: not available, EN high
  - DIO70040L: available, EN low
  - DIO70040NL: not available, EN low

### ■ Applications

- USB ports / hubs
- Digital TV
- Set-top boxes
- VOIP phones

### ■ Package Information

| Part Number | Package  | Body Size         |
|-------------|----------|-------------------|
| DIO70040    | SOT23-5  | 2.93 mm × 1.63 mm |
|             | SOIC-8   | 4.90 mm × 3.90 mm |
|             | EP-MSOP8 | 3.00 mm × 3.00 mm |
|             | MSOP-8   | 3.00 mm × 3.00 mm |

### ■ Description

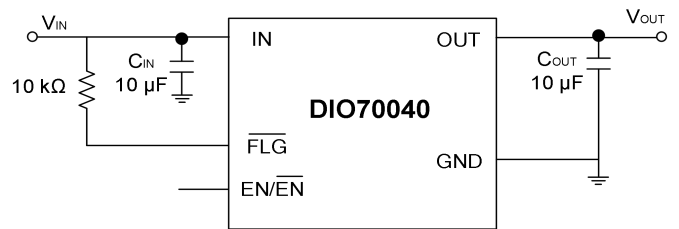
The DIO70040 power distribution switch is intended for applications where precision current limiting is required or heavy capacitive loads and short circuits are encountered. The power switch rising and falling times are controlled to minimize current surges during turning on / off.

The DIO70040 provides separately 500 mA/1 A/1.5 A/2 A/2.5 A five current levels.

The DIO70040 device limits the output current under a safe level by using a constant current mode when the output load exceeds the current limit threshold.

The DIO70040 is available in the SOT23-5, SOIC-8, EP-MSOP8 and MSOP-8 packages. It is rated over the -40°C to 85°C temperature range.

### ■ Simplified Schematic



## ■ Ordering Information

| Ordering Part No. | Top Marking | MSL | RoHS  | T <sub>A</sub> | Package  |                   |
|-------------------|-------------|-----|-------|----------------|----------|-------------------|
| DIO70040HXST5     | 4VHXW       | 3   | Green | -40 to 85°C    | SOT23-5  | Tape & Reel, 3000 |
| DIO70040NHXST5    | 4NHXW       | 3   | Green | -40 to 85°C    | SOT23-5  | Tape & Reel, 3000 |
| DIO70040LXST5     | 4VLXW       | 3   | Green | -40 to 85°C    | SOT23-5  | Tape & Reel, 3000 |
| DIO70040NLXST5    | 4NLXW       | 3   | Green | -40 to 85°C    | SOT23-5  | Tape & Reel, 3000 |
| DIO70040HXSO8     | D740HX      | 3   | Green | -40 to 85°C    | SOIC-8   | Tape & Reel, 2500 |
| DIO70040NHXSO8    | D74NHX      | 3   | Green | -40 to 85°C    | SOIC-8   | Tape & Reel, 2500 |
| DIO70040LXSO8     | D740LX      | 3   | Green | -40 to 85°C    | SOIC-8   | Tape & Reel, 2500 |
| DIO70040NLXSO8    | D74NLX      | 3   | Green | -40 to 85°C    | SOIC-8   | Tape & Reel, 2500 |
| DIO70040HXXM8     | D740HX      | 3   | Green | -40 to 85°C    | EP-MSOP8 | Tape & Reel, 3000 |
| DIO70040NHXXM8    | D74NHX      | 3   | Green | -40 to 85°C    | EP-MSOP8 | Tape & Reel, 3000 |
| DIO70040LXXM8     | D740LX      | 3   | Green | -40 to 85°C    | EP-MSOP8 | Tape & Reel, 3000 |
| DIO70040NLXXM8    | D74NLX      | 3   | Green | -40 to 85°C    | EP-MSOP8 | Tape & Reel, 3000 |
| DIO70040HXM8P8    | D740HX      | 3   | Green | -40 to 85°C    | MSOP-8   | Tape & Reel, 3000 |
| DIO70040NHXM8P8   | D74NHX      | 3   | Green | -40 to 85°C    | MSOP-8   | Tape & Reel, 3000 |
| DIO70040LXM8P8    | D740LX      | 3   | Green | -40 to 85°C    | MSOP-8   | Tape & Reel, 3000 |
| DIO70040NLXM8P8   | D74NLX      | 3   | Green | -40 to 85°C    | MSOP-8   | Tape & Reel, 3000 |

## ■ Ordering Information Complementary Note

Ordering Number = Part No. + H/L: Enable Active Version + X: Current Limit Version + Package Code

DIO70040: quick output discharge available

DIO70040N: quick output discharge not available

H: Enable active high

L: Enable active low

ST5: stands for SOT23-5

SO8: stands for SOIC-8

XM8: stands for EP-MSOP8

MP8: stands for MSOP-8

A: 500 mA current limit version (typ)

B: 1 A current limit version (typ)

C: 1.5 A current limit version (typ)

D: 2 A current limit version (typ)

E: 2.5 A current limit version (typ)

If you encounter any issue in the process of using the device, please contact our customer service at [marketing@diao.com](mailto:marketing@diao.com) or phone us at (+86)-21-62116882. If you have any improvement suggestions regarding the datasheet, we encourage you to contact our technical writing team at [docs@diao.com](mailto:docs@diao.com). Your feedback is invaluable for us to provide a better user experience.

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## 1. Pin Assignment and Functions

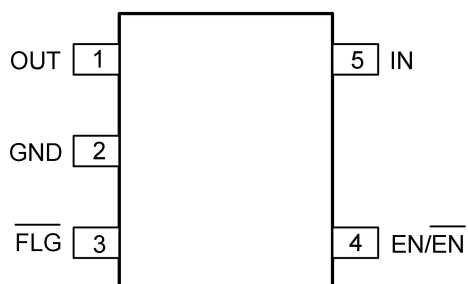


Figure 1. SOT23-5 (Top view)

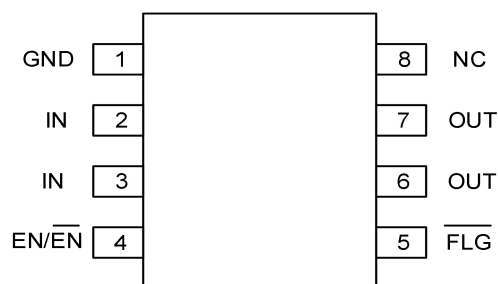


Figure 2. SOIC-8/MSOP-8 (Top view)

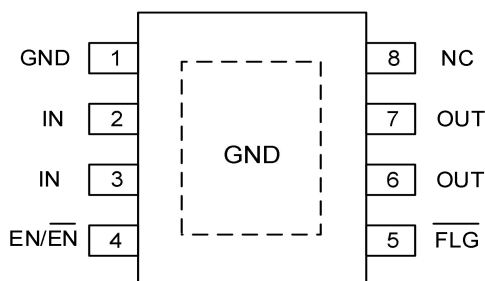


Figure 3. EP-MSOP8 (Top view)

| Name              | Description                                                                                                   |
|-------------------|---------------------------------------------------------------------------------------------------------------|
| OUT               | Output pin, decoupled with a 10 $\mu$ F capacitor to GND                                                      |
| GND               | Ground pin                                                                                                    |
| FLG               | Fault flag output                                                                                             |
| EN / EN           | Active high or Active low. Do not leave it floating                                                           |
| IN                | Input pin, decoupled with a 10 $\mu$ F capacitor to GND                                                       |
| Thermal pad (GND) | Internally connect to GND. Recommend to connect to a large ground plane for the improved thermal performance. |

## 2. Absolute Maximum Ratings

Exceeding the maximum ratings listed under Absolute Maximum Ratings when designing is likely to damage the device permanently. Do not design to the maximum limits because long-time exposure to them might impact the device's reliability. The ratings are obtained over an operating free-air temperature range unless otherwise specified.

| Symbol    | Parameter                                    | Rating     | Unit |
|-----------|----------------------------------------------|------------|------|
| $V_{IN}$  | Operation voltage                            | -0.3 ~ 6.0 | V    |
| $T_J$     | Maximum junction temperature                 | 150        | °C   |
| $T_{STG}$ | Storage temperature                          | -65 ~ 150  | °C   |
| $T_L$     | Maximum lead temperature (Soldering, 10 sec) | 260        | °C   |

## 3. Recommended Operating Conditions

Recommended operating conditions are specified to ensure optimal performance to the datasheet specifications. The ratings are obtained over an operating free-air temperature range unless otherwise specified.

| Symbol   | Parameter                          | Rating     | Unit |
|----------|------------------------------------|------------|------|
| $V_{IN}$ | Operation voltage                  | 2.7 ~ 5.5  | V    |
|          | Terminal voltage at all other pins | 0 ~ 5.5    | V    |
| $T_J$    | Junction temperature range         | -40 to 125 | °C   |
| $T_A$    | Ambient temperature range          | -40 to 85  | °C   |

## 4. ESD Ratings

When a statically-charged person or object touches an electrostatic discharge sensitive device, the electrostatic charge might be drained through sensitive circuitry in the device. If the electrostatic discharge possesses sufficient energy, damage might occur to the device due to localized overheating.

| Model                | Condition              | Value | Unit |
|----------------------|------------------------|-------|------|
| Human-body model     | ANSI/ESDA/JEDEC JS-001 | ±2    | kV   |
| Charged-device model | ANSI/ESDA/JEDEC JS-002 | ±2    | kV   |

## 5. Thermal Considerations

The thermal resistance determines the heat insulation property of a material. The higher the thermal resistance is, the lower the heat loss. Accumulation of heat energy degrades the performance of semiconductor components.

| Symbol           | Metric                                 |          | Value | Unit |
|------------------|----------------------------------------|----------|-------|------|
| R <sub>θJA</sub> | Junction-to-ambient thermal resistance | SOT23-5  | 250   | °C/W |
|                  |                                        | SOIC-8   | 130   |      |
|                  |                                        | EP-MSOP8 | 100   |      |
|                  |                                        | MSOP-8   | 166   |      |

## 6. Electrical Characteristics

Typical value:  $T_A = 25^\circ\text{C}$ ,  $V_{IN} = 5\text{ V}$ , unless otherwise specified.

| Symbol              | Parameter                                  | Conditions                                                     | Min  | Typ | Max               | Unit             |
|---------------------|--------------------------------------------|----------------------------------------------------------------|------|-----|-------------------|------------------|
| $V_{IN}$            | Input voltage range                        |                                                                | 2.7  |     | 5.5               | V                |
| $I_{SHDN}$          | Shut down input current                    | Open load, IC disabled                                         |      | 0.2 | 1                 | $\mu\text{A}$    |
| $I_Q$               | Quiescent supply current                   | Open load, IC enabled                                          |      | 36  | 60                | $\mu\text{A}$    |
| $R_{DS(ON)}$        | FET $R_{ON}$                               | $I_{OUT} = 100\text{ mA}$ , $T_A = 25^\circ\text{C}$           |      | 57  | 70                | $\text{m}\Omega$ |
|                     |                                            | $I_{OUT} = 100\text{ mA}$<br>$T_A = -40 \sim 85^\circ\text{C}$ |      | 57  | 80 <sup>(1)</sup> |                  |
| $V_{EN(H)}$         | EN rising threshold                        | $V_{IN} = 2.7\text{ V to } 5.5\text{ V}$                       | 0.85 |     |                   | V                |
| $V_{EN(L)}$         | EN falling threshold                       | $V_{IN} = 2.7\text{ V to } 5.5\text{ V}$                       |      |     | 0.4               | V                |
| $I_{EN}$            | EN leakage current                         | $V_{EN} = 5.0\text{ V}$                                        |      |     | 1                 | $\mu\text{A}$    |
| $V_{IN\_UVLO}$      | IN UVLO threshold                          |                                                                |      |     | 2.5               | V                |
| $V_{IN\_HYS}^{(1)}$ | IN UVLO hysteresis                         |                                                                |      | 150 | 400               | mV               |
| $I_{LIM}$           | Current limit                              | DIO70040 - A                                                   | 0.45 | 0.5 | 0.55              | A                |
|                     |                                            | DIO70040 - B                                                   | 0.9  | 1   | 1.1               |                  |
|                     |                                            | DIO70040 - C                                                   | 1.35 | 1.5 | 1.65              |                  |
|                     |                                            | DIO70040 - D                                                   | 1.8  | 2   | 2.2               |                  |
|                     |                                            | DIO70040 - E                                                   | 2.25 | 2.5 | 2.75              |                  |
|                     | Output reverse voltage fault deglitch time |                                                                | 2.5  | 4   | 7                 | ms               |
| $I_{SHORT}^{(1)}$   | Short-circuit current limit                | Enabled, output short to ground                                |      | 10% |                   | $I_{LIM}$        |
| $t_{ON}$            | EN turn-on time                            | $R_L = 10\ \Omega$ , $C_{OUT} = 1\ \mu\text{F}$                |      | 400 |                   | $\mu\text{s}$    |
| $t_{OFF}$           | EN turn-off time                           | $R_L = 10\ \Omega$ , $C_{OUT} = 1\ \mu\text{F}$                |      | 7   |                   | $\mu\text{s}$    |
| $t_R$               | Output turn-on rise time                   | $R_L = 100\ \Omega$ , 90% settling                             |      | 0.6 |                   | ms               |
| $t_F$               | Output turn-off time                       | $R_L = 100\ \Omega$ , 10% settling                             |      | 0.3 |                   | ms               |
| $T_{SD}$            | Thermal shutdown temperature               |                                                                |      | 140 |                   | $^\circ\text{C}$ |
|                     | Thermal shutdown hysteresis                |                                                                |      | 20  |                   | $^\circ\text{C}$ |
| $R_{DIS}$           | Discharge resistance                       |                                                                |      | 500 |                   | $\Omega$         |
| $V_{reverse}$       | Reverse voltage comparator trip point      |                                                                |      | 175 |                   | mV               |

**Note:**

- (1) Guaranteed by design.
- (2) Specifications subject to change without notice.

## 7. Typical Performance Characteristics

$T_A = 25^\circ\text{C}$ ,  $V_{IN} = 5\text{ V}$ , unless otherwise specified.

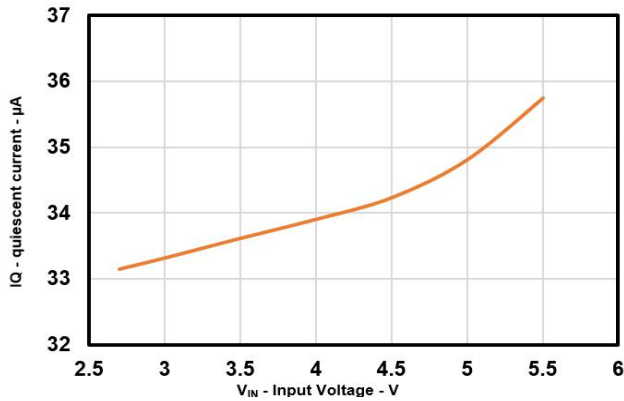


Figure 4. Quiescent current vs. Input voltage

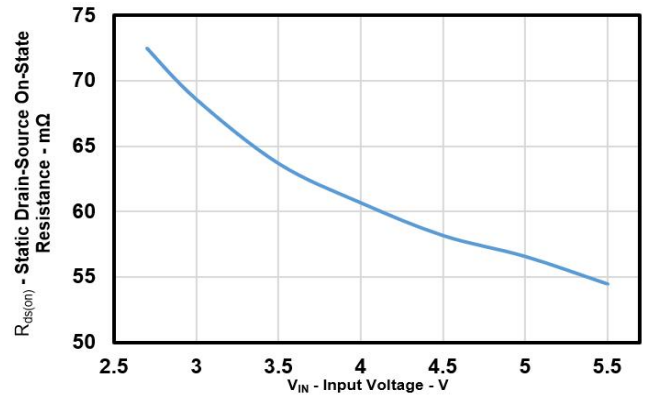


Figure 5. Static  $R_{DS(ON)}$  vs. Input voltage

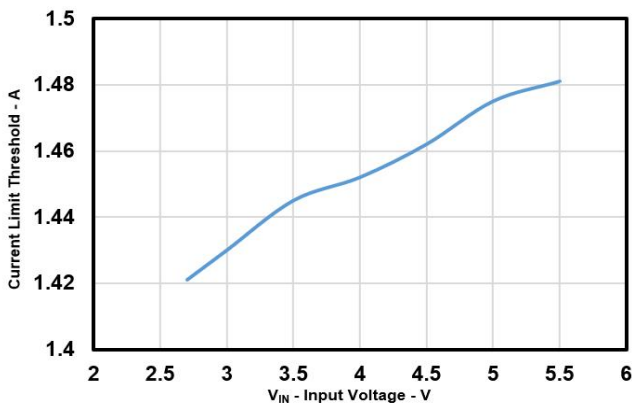


Figure 6. Current limit threshold vs. Input voltage

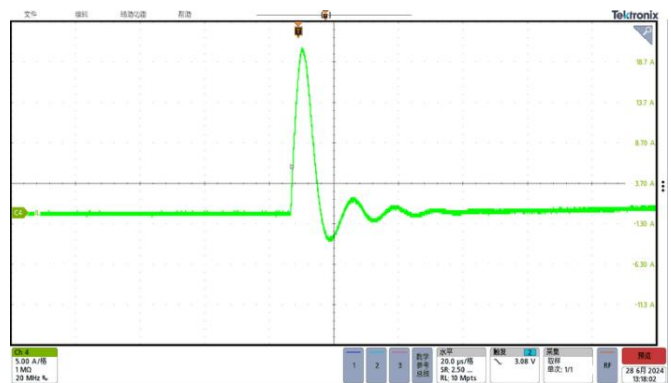


Figure 7. No-load to short-circuit response

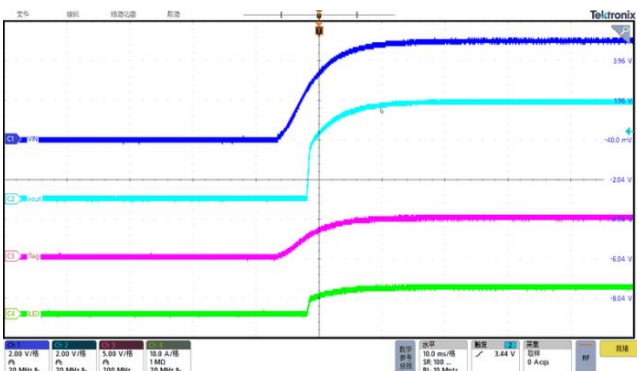


Figure 8. Input voltage turn on rise time

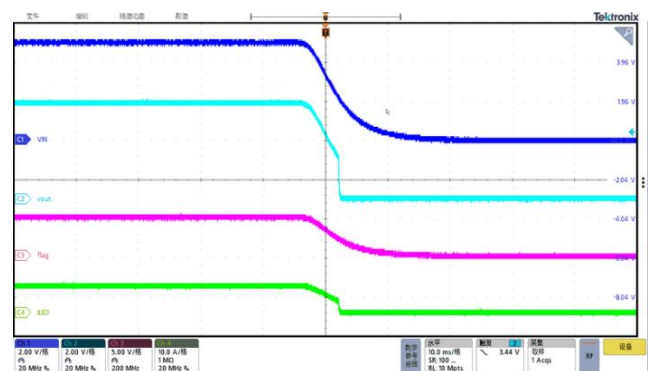
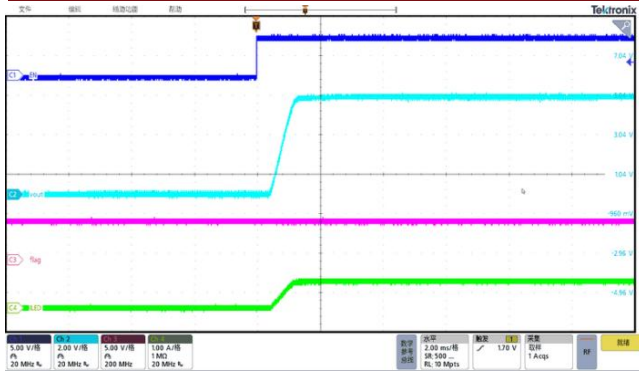
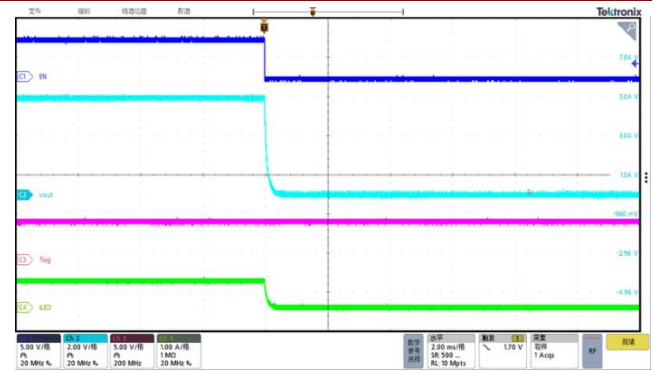


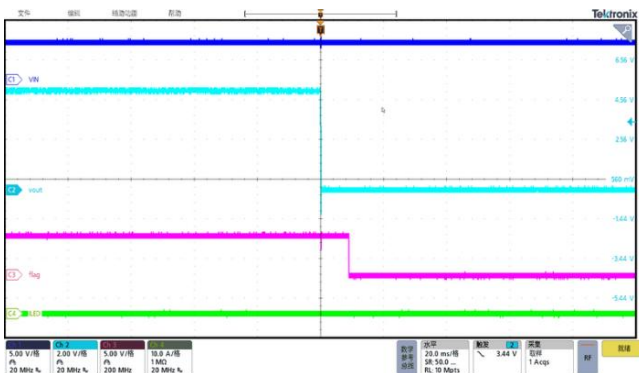
Figure 9. Input voltage turn off fall time



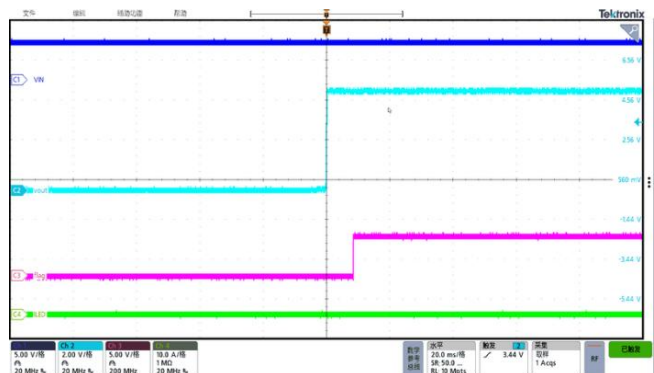
**Figure 10. Enable voltage turn on rise time**



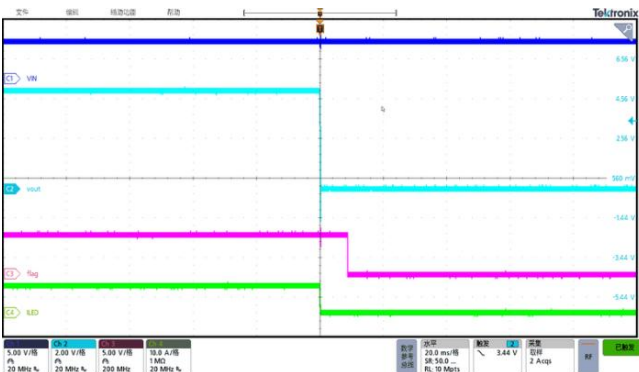
**Figure 11. Enable voltage turn off fall time**



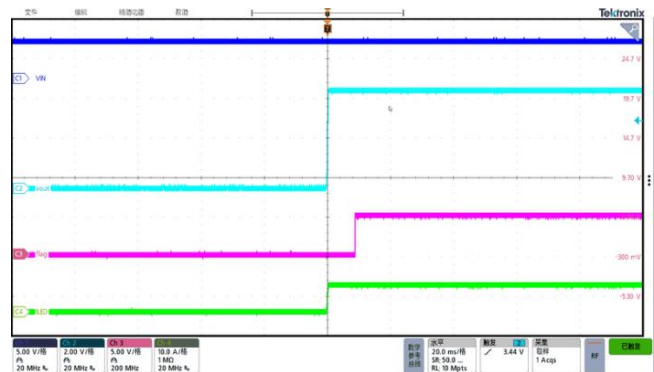
**Figure 12. No load to short transient response**



**Figure 13. Short to no load transient response**

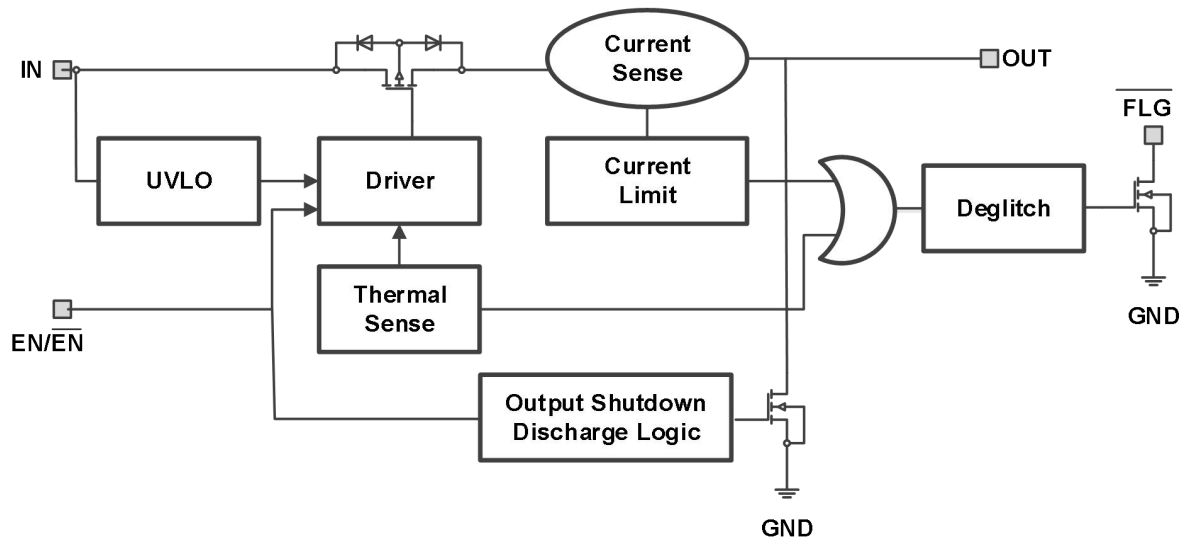


**Figure 14. Heavy load to short transient response**



**Figure 15. Short to heavy load transient response**

## 8. Block Diagram



## 9. Application Information

**Important notice:** Validation and testing are the most reliable ways to confirm system functionality. The application information is not part of the specification and is for reference purposes only.

### 9.1. Power supply considerations

A 10  $\mu$ F ceramic capacitor from  $V_{IN}$  to GND to prevent the input voltage from dropping during the hot-plug condition is strongly recommended. However higher capacitance could help reduce the voltage drop. Furthermore, bypassing the output with a 10  $\mu$ F ceramic capacitor improves the immunity of the device to short-circuit transients, because an output short will cause ringing on the input without the input capacitor. It could destroy the internal circuitry when the input transient voltage exceeds the absolute maximum supply voltage even for a short duration.

### 9.2. Undervoltage lockout

The undervoltage lockout (UVLO) circuit disables the power switch until the input voltage reaches the UVLO turn-on threshold. Built-in hysteresis prevents unwanted on / off cycling due to input voltage drop from large current surges.

### 9.3. Enable

The logic enable controls the power switch, driver, and other circuitry to reduce the supply current. The EN /  $\overline{EN}$  control pin must be driven to a logic high or logic low for a clearly defined signal input. Floating these control lines may cause unpredictable operation.

### 9.4. Overcurrent protection

The DIO70040 responds to over current conditions by limiting output current to the  $I_{LIM}$  levels. When an over current condition is detected, the device maintains a constant output current and reduces the output voltage accordingly. Complete shut down occurs only if the fault is present long enough to activate thermal limit.

Three possible overload conditions can occur. In the first condition, the output has been shorted to GND before the device is enabled or before  $V_{IN}$  has been applied. The DIO70040 senses the short circuit and immediately clamps output current to a certain safe level.

In the second condition, an excessive load occurs while the device is enabled. When the excessive load occurs, very high currents may flow for a short time before the current limit circuit can react. After the current limit circuit has tripped (reached the overcurrent trip threshold) the device switches into constant current mode to limit the current close to  $I_{LIM}$ .

In the third condition the load is gradually increasing beyond the recommended operating current. The current is permitted to rise until the current limit threshold ( $I_{LIM}$ ) is reached or until the thermal limit of the device is exceeded. The DIO70040 is capable of delivering current up to the current limit threshold ( $I_{LIM}$ ) without damaging the device. Once the threshold has been reached, the device switches into its constant current mode.

## 9.5. Thermal protection

Thermal protection prevents damage to the IC when heavy overload or short circuit conditions are present for extended periods of time. The conditions force the DIO70040 into constant current mode, and under short circuit conditions, the voltage across the switch is equal to the input voltage. The increased dissipation causes the junction temperature to rise to high levels. The protection circuit senses the junction temperature of the switch and shuts it off. Hysteresis is built into the thermal sense circuit, and after the device has cooled approximately 20 degrees, the switch turns back on. The switch continues to cycle in this way until the overload or input power is removed.

## 9.6. Reverse-voltage protection

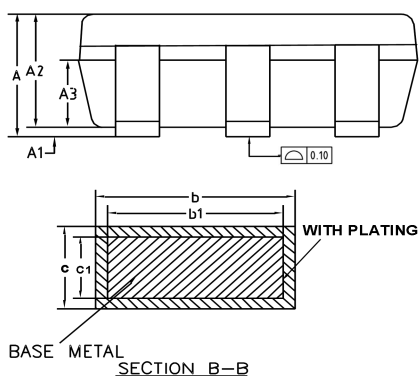
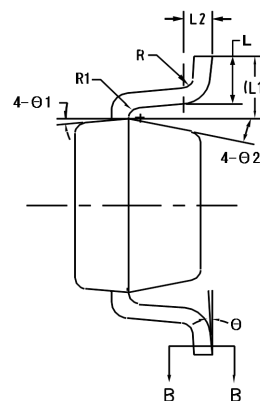
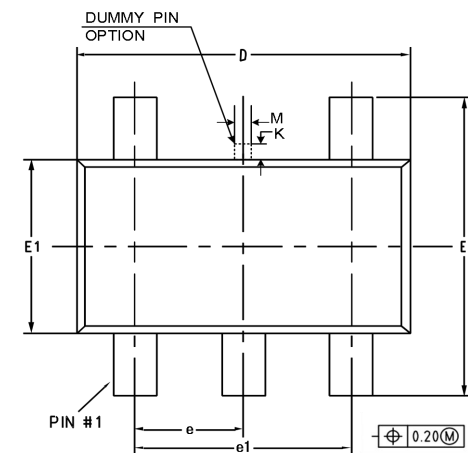
The reverse-voltage protection feature turns off the P-channel MOSFET whenever the output voltage exceeds the input voltage by 175 mV (typ). A reverse current of  $(V_{OUT} - V_{IN}) / R_{DS(ON)}$  will be present when this occurs. This prevents damage to devices on the input side of the DIO70040 by preventing significant current from sinking into the input capacitance. The DIO70040 devices allow the P-channel MOSFET to turn on once the output voltage goes below the input voltage.

## 9.7. $\overline{FLG}$ output

Error flag is an open-drain output of a N-channel MOSFET. If current limiting or short circuit occurs,  $\overline{FLG}$  is pulled low after a delay of 8 ms (typ), and if no current limiting or short circuit occurs,  $\overline{FLG}$  is pulled high after a delay of 8 ms (typ). If reverse-voltage protection occurs,  $\overline{FLG}$  is pulled low after a delay of 4 ms (typ), and if no reverse-voltage protection occurs,  $\overline{FLG}$  is pulled high after a delay of 4 ms (typ). If overtemperature protection occurs,  $\overline{FLG}$  is pulled low immediately, and if no overtemperature protection occurs,  $\overline{FLG}$  is pulled high after a delay of 8 ms (typ).

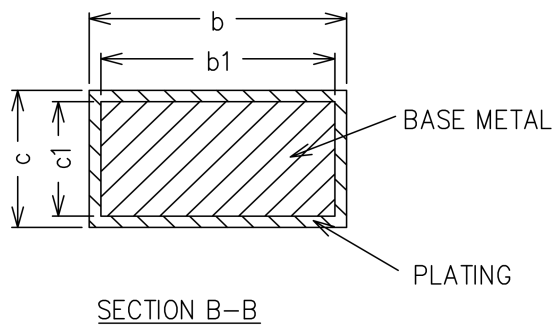
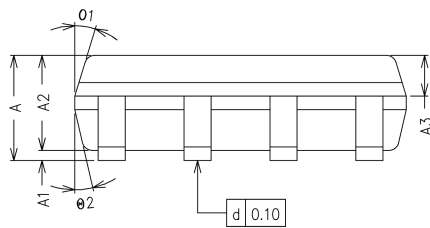
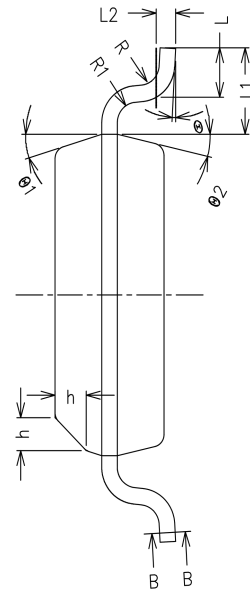
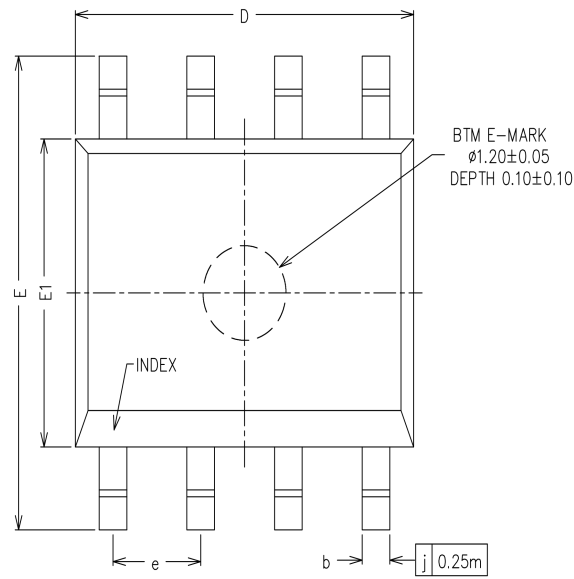
## 10. Physical Dimension

### 10.1. SOT23-5



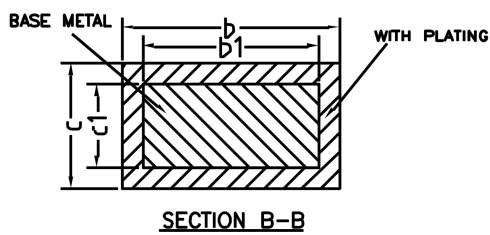
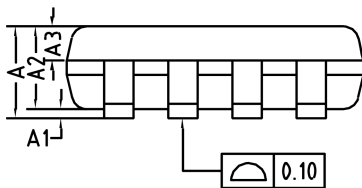
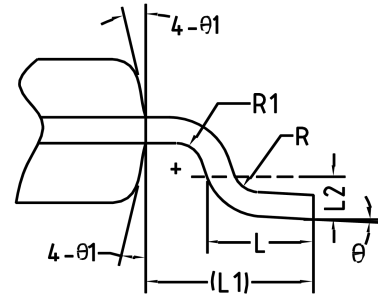
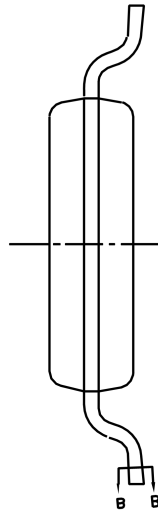
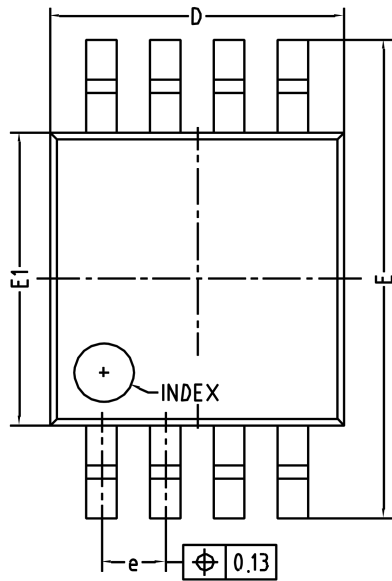
| Common Dimensions<br>(Units of measure = Millimeter) |          |       |       |
|------------------------------------------------------|----------|-------|-------|
| Symbol                                               | Min      | Nom   | Max   |
| A                                                    | -        | -     | 1.25  |
| A1                                                   | 0        | -     | 0.15  |
| A2                                                   | 1.00     | 1.10  | 1.20  |
| A3                                                   | 0.60     | 0.65  | 0.70  |
| b                                                    | 0.36     | -     | 0.45  |
| b1                                                   | 0.35     | 0.38  | 0.41  |
| c                                                    | 0.14     | -     | 0.20  |
| c1                                                   | 0.14     | 0.15  | 0.16  |
| D                                                    | 2.826    | 2.926 | 3.026 |
| E                                                    | 2.60     | 2.80  | 3.00  |
| E1                                                   | 1.526    | 1.626 | 1.726 |
| e                                                    | 0.90     | 0.95  | 1.00  |
| e1                                                   | 1.80     | 1.90  | 2.00  |
| K                                                    | 0        | -     | 0.25  |
| L                                                    | 0.30     | 0.40  | 0.60  |
| L1                                                   | 0.59 REF |       |       |
| L2                                                   | 0.25 BSC |       |       |
| M                                                    | 0.10     | 0.15  | 0.25  |
| R                                                    | 0.05     | -     | 0.20  |
| R1                                                   | 0.05     | -     | 0.20  |
| θ                                                    | 0°       | -     | 8°    |
| θ1                                                   | 8°       | 10°   | 12°   |
| θ2                                                   | 10°      | 12°   | 14°   |

## 10.2. SOIC-8



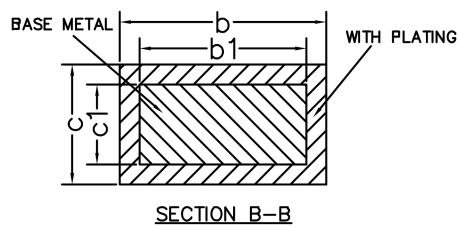
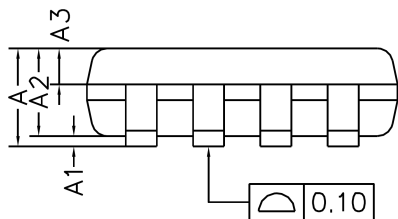
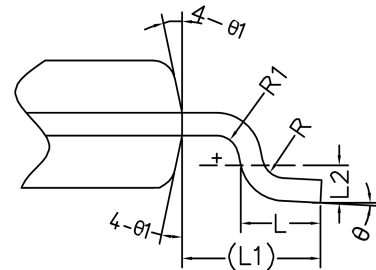
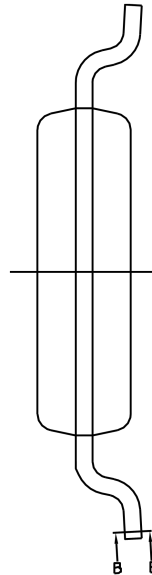
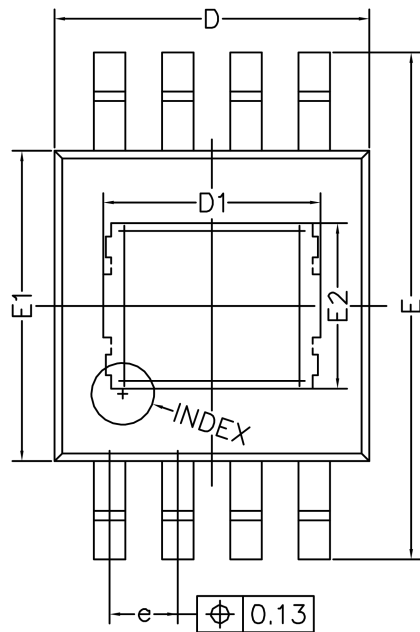
| Common Dimensions<br>(Units of measure = Millimeter) |          |      |      |
|------------------------------------------------------|----------|------|------|
| Symbol                                               | Min      | Nom  | Max  |
| A                                                    | 1.35     | 1.55 | 1.75 |
| A1                                                   | 0.10     | -    | 0.25 |
| A2                                                   | 1.30     | 1.40 | 1.50 |
| A3                                                   | 0.50     | 0.60 | 0.70 |
| b                                                    | 0.38     | -    | 0.47 |
| b1                                                   | 0.37     | 0.40 | 0.43 |
| c                                                    | 0.17     | -    | 0.25 |
| c1                                                   | 0.17     | 0.20 | 0.23 |
| D                                                    | 4.80     | 4.90 | 5.00 |
| E                                                    | 5.80     | 6.00 | 6.20 |
| E1                                                   | 3.80     | 3.90 | 4.00 |
| e                                                    | 1.17     | 1.27 | 1.37 |
| L                                                    | 0.45     | 0.60 | 0.80 |
| L1                                                   | 1.04 REF |      |      |
| L2                                                   | 0.25 BSC |      |      |
| R                                                    | 0.07     | -    | -    |
| R1                                                   | 0.07     | -    | -    |
| h                                                    | 0.30     | 0.40 | 0.50 |
| θ                                                    | 0°       | -    | 8°   |
| θ1                                                   | 15°      | 17°  | 19°  |
| θ2                                                   | 11°      | 13°  | 15°  |

### 10.3. MSOP-8



| Common Dimensions<br>(Units of measure = Millimeter) |          |      |      |
|------------------------------------------------------|----------|------|------|
| Symbol                                               | Min      | Nom  | Max  |
| A                                                    | -        | -    | 1.10 |
| A1                                                   | 0.05     | 0.10 | 0.15 |
| A2                                                   | 0.75     | 0.85 | 0.95 |
| A3                                                   | 0.30     | 0.35 | 0.40 |
| b                                                    | 0.25     | -    | 0.38 |
| b1                                                   | 0.24     | 0.30 | 0.33 |
| c                                                    | 0.15     | -    | 0.20 |
| c1                                                   | 0.14     | 0.15 | 0.16 |
| D                                                    | 2.90     | 3.00 | 3.10 |
| E                                                    | 4.75     | 4.90 | 5.05 |
| E1                                                   | 2.90     | 3.00 | 3.10 |
| e                                                    | 0.55     | 0.65 | 0.75 |
| L                                                    | 0.40     | 0.55 | 0.70 |
| L1                                                   | 0.95 REF |      |      |
| L2                                                   | 0.25 BSC |      |      |
| R                                                    | 0.07     | -    | -    |
| R1                                                   | 0.07     | -    | -    |
| θ                                                    | 0°       | -    | 8°   |
| θ1                                                   | 9°       | 12°  | 15°  |

## 10.4. EP-MSOP8



| Common Dimensions<br>(Units of measure = Millimeter) |          |      |      |
|------------------------------------------------------|----------|------|------|
| Symbol                                               | Min      | Nom  | Max  |
| A                                                    | -        | -    | 1.10 |
| A1                                                   | 0.05     | 0.10 | 0.15 |
| A2                                                   | 0.75     | 0.85 | 0.95 |
| A3                                                   | 0.30     | 0.35 | 0.40 |
| b                                                    | 0.25     | -    | 0.38 |
| b1                                                   | 0.24     | 0.30 | 0.33 |
| c                                                    | 0.13     | -    | 0.20 |
| c1                                                   | 0.13     | 0.15 | 0.16 |
| D                                                    | 2.90     | 3.00 | 3.10 |
| D1                                                   | 1.92     | 2.07 | 2.22 |
| E                                                    | 4.75     | 4.90 | 5.05 |
| E1                                                   | 2.90     | 3.00 | 3.10 |
| E2                                                   | 1.45     | 1.60 | 1.75 |
| e                                                    | 0.55     | 0.65 | 0.75 |
| L                                                    | 0.40     | 0.55 | 0.70 |
| L1                                                   | 0.95 REF |      |      |
| L2                                                   | 0.25 BSC |      |      |
| R                                                    | 0.07     | -    | -    |
| R1                                                   | 0.07     | -    | -    |
| θ                                                    | 0°       | -    | 8°   |
| θ1                                                   | 9°       | 12°  | 15°  |

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