

SLG59M1641V

Ultra-small 2-Channel 45 mΩ/2 A Load Switch with Reverse-Current Blocking

General Description

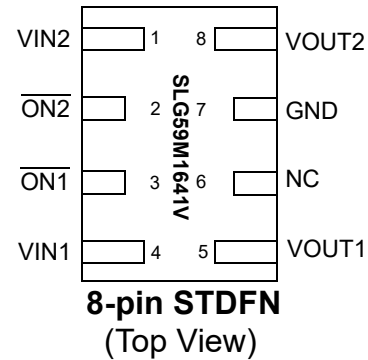
The SLG59M1641V is a dual-channel, 45 mΩ pFET load switch designed to switch 1.5 V to 5.5 V power rails up to 2 A in each channel. When either channel is enabled, reverse-current protection will quickly open the switch in the event of a reverse-voltage condition is detected (a $V_{OUT} > V_{IN} + 50$ mV condition opens the switch). In the event that the channel's V_{IN} voltage is too low, the load switch also contains an internal $V_{IN(UVLO)}$ threshold monitor to keep or to turn the switch OFF. Each load switch is independently controlled via its own low-voltage compatible CMOS input.

Designed to operate over a -40°C to 85°C range, the SLG59M1641V is available in a RoHS-compliant, ultra-small 1.6 x 1.0 mm STDFN package.

Features

- Integrated 2-Channel pFET Load Switch
- 2 A Maximum Continuous Switch Current per Channel
- Low Typical $R_{DS(ON)}$:
 - 45 mΩ at $V_{IN} = 5$ V
 - 60 mΩ at $V_{IN} = 2.5$ V
 - 80 mΩ at $V_{IN} = 1.5$ V
- Operating Voltage: 1.5 V to 5.5 V
- Reverse-current/voltage Protection
- Low-voltage CMOS Logic Compatible Switch Control
- Operating temperature range: -40°C to 85°C
- Pb-Free / Halogen-Free / RoHS compliant packaging

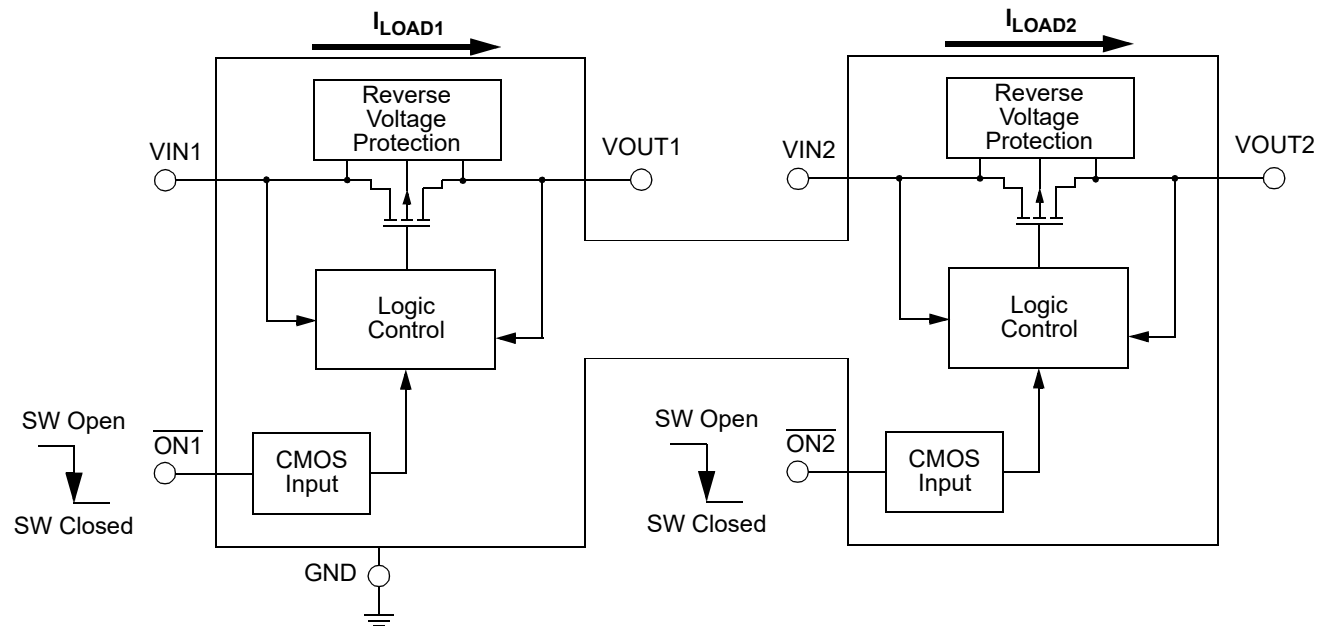
Pin Configuration



Applications

- Power-Rail Switching:
 - Notebook/Laptop/Tablet PCs
 - Smartphones/Wireless Handsets
 - High-definition Digital Cameras
 - Set-top Boxes
- Point of Sales Pins
- GPS Navigation Devices

Block Diagram



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Pin Description

| Pin # | Pin Name | Type | Pin Description |
|-------|-------------------------|------------|---|
| 1 | VIN2 | MOSFET | Input and source terminal of MOSFET #2. Bypass the VIN2 pin to GND with a 10 μF (or larger), low-ESR capacitor. |
| 2 | $\overline{\text{ON2}}$ | Input | $\overline{\text{ON2}}$ turns Channel 2 MOSFET ON and is a low logic-level CMOS input with $\text{ON_V}_{\text{IL}} < 0.3 \text{ V}$ and $\text{ON_V}_{\text{IH}} > 1 \text{ V}$. As the $\overline{\text{ON2}}$ input circuit does not have an internal pull-down resistor, connect $\overline{\text{ON2}}$ pin directly to a GPIO controller – do not allow this pin to be open circuited. |
| 3 | $\overline{\text{ON1}}$ | Input | $\overline{\text{ON1}}$ turns Channel 1 MOSFET ON and is a low-logic level CMOS input with $\text{ON_V}_{\text{IL}} < 0.3 \text{ V}$ and $\text{ON_V}_{\text{IH}} > 1 \text{ V}$. As the $\overline{\text{ON1}}$ input circuit does not have an internal pull-down resistor, connect $\overline{\text{ON1}}$ pin directly to a GPIO controller – do not allow this pin to be open circuited. |
| 4 | VIN1 | MOSFET | Input and source terminal of MOSFET #1. Bypass the VIN1 pin to GND with a 10 μF (or larger), low-ESR capacitor. |
| 5 | VOUT1 | MOSFET | Output and drain terminal of MOSFET #1. |
| 6 | NC | No Connect | No connection. Do not make connection to any other pin - leave Pin 6 as an open circuit. |
| 7 | GND | GND | Ground connection. Connect this pin to system analog or power ground plane. |
| 8 | VOUT2 | MOSFET | Output and drain terminal of MOSFET #2. |

Ordering Information

| Part Number | Type | Production Flow |
|---------------|-----------------------|-----------------------------|
| SLG59M1641V | STDFN | Industrial, -40 °C to 85 °C |
| SLG59M1641VTR | STDFN (Tape and Reel) | Industrial, -40 °C to 85 °C |

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Absolute Maximum Ratings

| Parameter | Description | Conditions | Min. | Typ. | Max. | Unit |
|-------------------------------|-------------------------------------|--|------|------|------|------|
| $V_{IN[1,2]}$ | Load Switch Input Voltage | | -0.3 | -- | 6 | V |
| T_S | Storage Temperature | | -65 | -- | 150 | °C |
| ESD _{HBM} | ESD Protection | Human Body Model | 2000 | -- | -- | V |
| ESD _{CDM} | ESD Protection | Charged Device Model | 1000 | -- | -- | V |
| MSL | Moisture Sensitivity Level | | 1 | | | |
| θ_{JA} | Thermal Resistance | 1.0 x 1.6 mm 8L STDFN | -- | 82 | -- | °C/W |
| $T_{J,MAX}$ | Maximum Junction Temperature | | -- | 150 | -- | °C |
| MOSFET IDS _{CONT} | Continuous Current from VIN to VOUT | Each channel, $T_J < 150^\circ\text{C}$ | -- | -- | 2 | A |
| MOSFET IDS _{PK} | Peak Current from Drain to Source | Maximum pulsed switch current, pulse width < 1 ms, 1% duty cycle | -- | -- | 2.5 | A |

Note: Stresses greater than those listed under "Absolute Maximum Ratings" may cause permanent damage to the device. This is a stress rating only and functional operation of the device at these or any other conditions above those indicated in the operational sections of this specification is not implied. Exposure to absolute maximum rating conditions for extended periods may affect reliability.

Electrical Characteristics

$1.5\text{ V} \leq V_{IN[1,2]} \leq 5.5\text{ V}$; $C_{IN} = 10\text{ }\mu\text{F}$, $T_A = -40^\circ\text{C}$ to 85°C , unless otherwise noted.

Typical values are at $T_A = 25^\circ\text{C}$ (unless otherwise stated)

| Parameter | Description | Conditions | Min. | Typ. | Max. | Unit |
|-------------------|---|--|------|------|----------|---------------|
| $V_{IN[1,2]}$ | Switch Input Voltage | | 1.5 | -- | 5.5 | V |
| $V_{IN(UVLO)}$ | V_{IN} Undervoltage Lockout Threshold | $V_{IN} \uparrow$, $V_{ON} = 0\text{ V}$, $R_{LOAD} = 10\text{ }\Omega$ | -- | -- | 1.2 | V |
| | | $V_{IN} \downarrow$, $V_{ON} = 0\text{ V}$, $R_{LOAD} = 10\text{ }\Omega$ | 0.5 | -- | -- | V |
| I_{IN} | Quiescent Supply Current, Both Channels | $V_{IN} = 5.25\text{ V}$, $V_{ON} = \text{LOW}$, $I_{DS} = 0\text{ mA}$ | -- | 3.5 | 5.3 | μA |
| | | $V_{IN} = 1.5\text{ V}$, $V_{ON} = \text{LOW}$, $I_{DS} = 0\text{ mA}$ | -- | 2.5 | 4 | μA |
| $I_{IN(OFF)}$ | OFF Mode Supply Current, Both Channels | $V_{IN} = 5.25\text{ V}$, $V_{ON} = V_{IN}$, $R_{LOAD} = 1\text{ M}\Omega$ | -- | 1 | 1.7 | μA |
| | | $V_{IN} = 1.5\text{ V}$, $V_{ON} = V_{IN}$, $R_{LOAD} = 1\text{ M}\Omega$ | -- | 0.4 | 1 | μA |
| $R_{DS(ON)}$ | Static Drain to Source ON Resistance | $T_A = 25^\circ\text{C}$, $V_{IN} = 5.0\text{ V}$, $I_{DS} = -200\text{ mA}$ | -- | 45 | 55 | mΩ |
| | | $T_A = 25^\circ\text{C}$, $V_{IN} = 2.5\text{ V}$, $I_{DS} = -200\text{ mA}$ | -- | 60 | 72 | mΩ |
| | | $T_A = 25^\circ\text{C}$, $V_{IN} = 1.5\text{ V}$, $I_{DS} = -200\text{ mA}$ | -- | 80 | 96 | mΩ |
| $V_{REVERSE}$ | Reverse-current Voltage Threshold | | -- | 50 | -- | mV |
| $I_{REVERSE}$ | Reverse-current Leakage Current after Reverse Current Event | $V_{IN} = 0\text{ V}$, $V_{OUT} = 1.5\text{ V}$ to 5.25 V ; $V_{ON1} = V_{ON2} = V_{OUT}$; $T_A = 25^\circ\text{C}$ | -- | 0.6 | 1.5 | μA |
| $V_{ON[1,2]}$ | $\overline{ON}[1,2]$ Pin Voltage Range | | 0 | -- | V_{IN} | V |
| $I_{ON(Leakage)}$ | $\overline{ON}[1,2]$ Pin Leakage Current | $1.4\text{ V} \leq V_{ON} \leq 5.25\text{ V}$ or $V_{ON} = \text{GND}$ | -- | -- | 1 | μA |
| ON_V_{IH} | $\overline{ON}[1,2]$ Pin Input High Voltage | | 1 | -- | V_{IN} | V |
| ON_V_{IL} | $\overline{ON}[1,2]$ Pin Input Low Voltage | | -0.3 | 0 | 0.3 | V |

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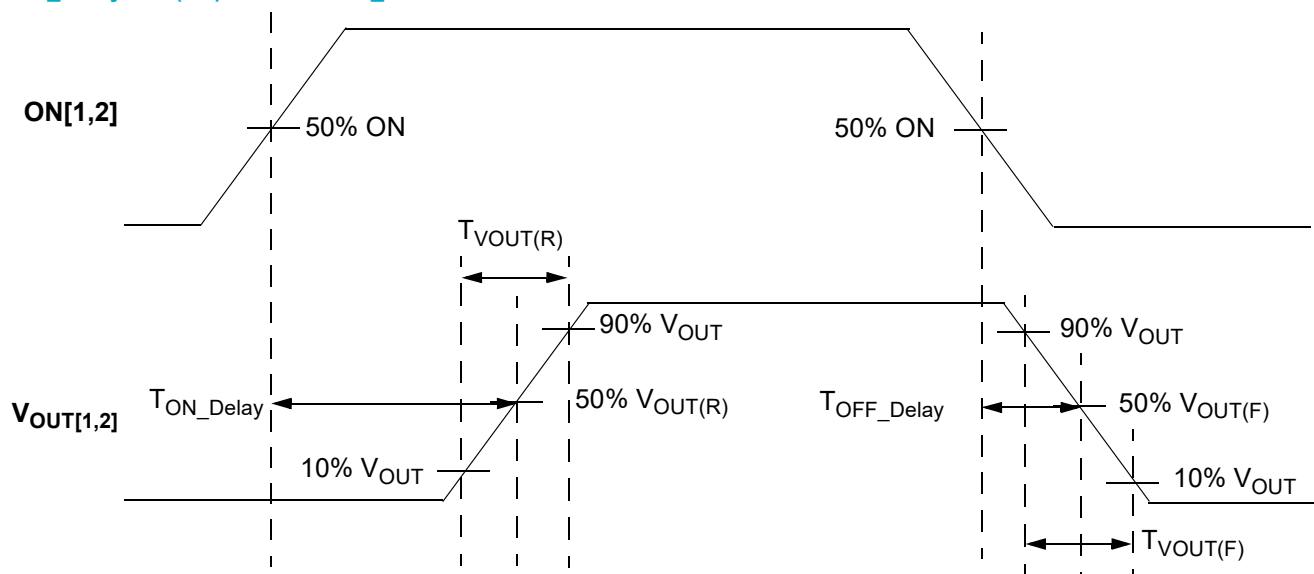
Electrical Characteristics (continued)

$1.5\text{ V} \leq V_{IN[1,2]} \leq 5.5\text{ V}$; $C_{IN} = 10\text{ }\mu\text{F}$, $T_A = -40\text{ }^\circ\text{C}$ to $85\text{ }^\circ\text{C}$, unless otherwise noted.

Typical values are at $T_A = 25\text{ }^\circ\text{C}$ (unless otherwise stated)

| Parameter | Description | Conditions | Min. | Typ. | Max. | Unit |
|------------------|---------------------------------------|---|------|------|------|---------------|
| ON_{HYS} | $\overline{ON}[1,2]$ Hysteresis | | -- | 60 | -- | mV |
| T_{REV} | Reverse-current Detect Response Delay | $V_{IN} = 5\text{ V}$ | -- | 10 | -- | μs |
| T_{REARM} | Reverse Detect Rearm Time | | -- | 16 | -- | μs |
| T_{ON_Delay} | $\overline{ON}[1,2]$ Delay Time | 50% \overline{ON} to 50% $V_{OUTx} \uparrow$; $T_A = 25\text{ }^\circ\text{C}$, $V_{INx} = 5\text{ V}$; $R_{LOAD} = 10\text{ }\Omega$, $C_{LOAD} = 0.1\text{ }\mu\text{F}$ | 0.9 | -- | 6 | μs |
| | | 50% \overline{ON} to 50% $V_{OUTx} \uparrow$; $T_A = 25\text{ }^\circ\text{C}$, $V_{INx} = 1.5\text{ V}$; $R_{LOAD} = 10\text{ }\Omega$, $C_{LOAD} = 0.1\text{ }\mu\text{F}$ | 30 | -- | 96 | μs |
| $T_{VOUT(R)}$ | $V_{OUT[1,2]}$ Rise Time | 10% to 90% $V_{OUTx} \uparrow$; $T_A = 25\text{ }^\circ\text{C}$, $V_{INx} = 5\text{ V}$; $R_{LOAD} = 10\text{ }\Omega$, $C_{LOAD} = 0.1\text{ }\mu\text{F}$ | 0.7 | 1.1 | 3.5 | μs |
| | | 10% to 90% $V_{OUTx} \uparrow$; $T_A = 25\text{ }^\circ\text{C}$, $V_{INx} = 1.5\text{ V}$; $R_{LOAD} = 10\text{ }\Omega$, $C_{LOAD} = 0.1\text{ }\mu\text{F}$ | 17 | 31 | 50 | μs |
| $T_{VOUT(F)}$ | $V_{OUT[1,2]}$ Fall Time | 90% to 10% $V_{OUTx} \downarrow$; $T_A = 25\text{ }^\circ\text{C}$, $V_{INx} = 5\text{ V}$; $R_{LOAD} = 10\text{ }\Omega$, $C_{LOAD} = 0.1\text{ }\mu\text{F}$ | -- | -- | 3 | μs |
| | | 90% to 10% $V_{OUTx} \downarrow$; $T_A = 25\text{ }^\circ\text{C}$, $V_{INx} = 1.5\text{ V}$; $R_{LOAD} = 10\text{ }\Omega$, $C_{LOAD} = 0.1\text{ }\mu\text{F}$ | -- | -- | 3.5 | μs |
| T_{OFF_Delay} | OFF Delay Time | 50% \overline{ONx} to 50% $V_{OUTx} \downarrow$; $T_A = 25\text{ }^\circ\text{C}$, $V_{INx} = 5\text{ V}$; $R_{LOAD} = 10\text{ }\Omega$, $C_{LOAD} = 0.1\text{ }\mu\text{F}$ | -- | -- | 15 | μs |
| | | 50% \overline{ONx} to 50% $V_{OUTx} \downarrow$; $T_A = 25\text{ }^\circ\text{C}$, $V_{INx} = 1.5\text{ V}$; $R_{LOAD} = 10\text{ }\Omega$, $C_{LOAD} = 0.1\text{ }\mu\text{F}$ | -- | -- | 10 | μs |

T_{ON_Delay} , $V_S(SR)$, and T_{Total_ON} Timing Details

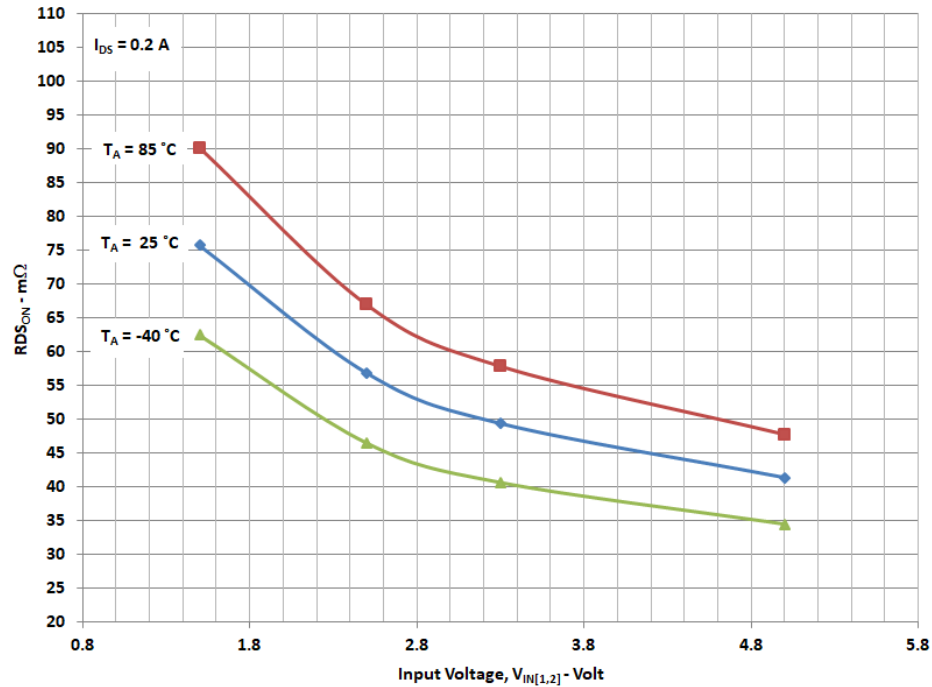


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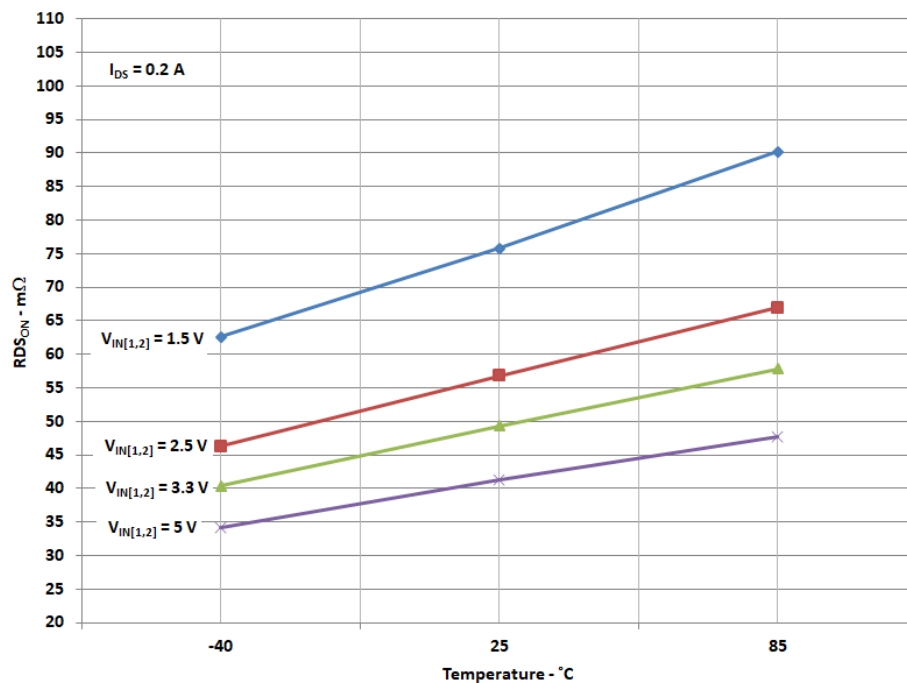
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Typical Performance Characteristics

$R_{DS(ON)}$ vs. $V_{IN[1,2]}$ and Temperature



$R_{DS(ON)}$ vs. Temperature and $V_{IN[1,2]}$



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V_{IN[1,2]} Inrush Current Details

When either channel of the SLG59M1641V is enabled with $\overline{\text{ON}}[1,2] \uparrow$, the load switch closes to charge the V_{OUT[1,2]} output capacitor to V_{IN[1,2]}. The charging current drawn from V_{IN[1,2]} is commonly referred to as “V_{IN} inrush current” and can cause the input power source to collapse if the V_{IN} inrush current is too high.

Since the V_{OUT[1,2]} rise time of the SLG59M1641V is fixed, V_{IN[1,2]} inrush current is then a function of the output capacitance at V_{OUT[1,2]}. The expression relating V_{IN[1,2]} inrush current, the SLG59M1641V V_{OUT[1,2]} rise time, and C_{LOAD[1,2]} is:

$$V_{IN[1,2]} \text{ Inrush Current} = C_{LOAD[1,2]} \times \frac{\Delta V_{OUT[1,2]}}{V_{OUT[1,2]} \text{ Rise Time}}$$

where in this expression ΔV_{OUT[1,2]} is equivalent to 0.8 x V_{IN[1,2]} if the initial SLG59M1641V's output voltages are zero.

In the table below are examples of V_{IN[1,2]} inrush currents assuming zero initial charge on C_{LOAD[1,2]} as a function of V_{IN[1,2]}.

| V _{IN[1,2]} | V _{OUT[1,2]} Rise Time | C _{LOAD[1,2]} | Inrush Current |
|----------------------|---------------------------------|------------------------|----------------|
| 1.5 V | 31 μs | 0.1 μF | 3.8 mA |
| 5 V | 1 μs | 0.1 μF | 400 mA |

Since the relationship is linear and if C_{LOAD[1,2]} were increased to 1 μF, then the V_{IN[1,2]} inrush currents would be 10x higher in either example. If a large C_{LOAD[1,2]} capacitor is required in the application and depending upon the strength of the input power source, it may very well be necessary to increase the C_{IN}-to-C_{LOAD} ratio to minimize V_{IN[1,2]} droop during turn-on.

For other V_{OUT[1,2]} rise time options, please contact Renesas for additional information.

Power Dissipation

The junction temperature of the SLG59M1641V depends on factors such as board layout, ambient temperature, external air flow over the package, load current, and the RDS_{ON}-generated voltage drop across each power MOSFET. While the primary contributor to the increase in the junction temperature of the SLG59M1641V is the power dissipation of its power MOSFETs, its power dissipation and the junction temperature in nominal operating mode can be calculated using the following equations:

$$PD_{TOTAL} = (RDS_{ON1} \times I_{DS1}^2) + (RDS_{ON2} \times I_{DS2}^2)$$

where:

PD_{TOTAL} = Total package power dissipation, in Watts (W)

RDS_{ON[1,2]} = Channel 1 and Channel 2 Power MOSFET ON resistance, in Ohms (Ω), respectively

I_{DS[1,2]} = Channel 1 and Channel 2 Output current, in Amps (A), respectively

and

$$T_J = PD_{TOTAL} \times \theta_{JA} + T_A$$

where:

T_J = Die junction temperature, in Celsius degrees (°C)

θ_{JA} = Package thermal resistance, in Celsius degrees per Watt (°C/W) – highly dependent on pcb layout

T_A = Ambient temperature, in Celsius degrees (°C)

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Power Dissipation (continued)

In nominal operating mode, the SLG59M1641V's power dissipation can also be calculated by taking into account the voltage drop across each switch ($V_{INx}-V_{OUTx}$) and the magnitude of that channel's output current (I_{DSx}):

$$PD_{TOTAL} = [(V_{IN1}-V_{OUT1}) \times I_{DS1}] + [(V_{IN2}-V_{OUT2}) \times I_{DS2}] \text{ or}$$

$$PD_{TOTAL} = [(V_{IN1} - (R_{LOAD1} \times I_{DS1})) \times I_{DS1}] + [(V_{IN2} - (R_{LOAD2} \times I_{DS2})) \times I_{DS2}]$$

where:

PD_{TOTAL} = Total package power dissipation, in Watts (W)

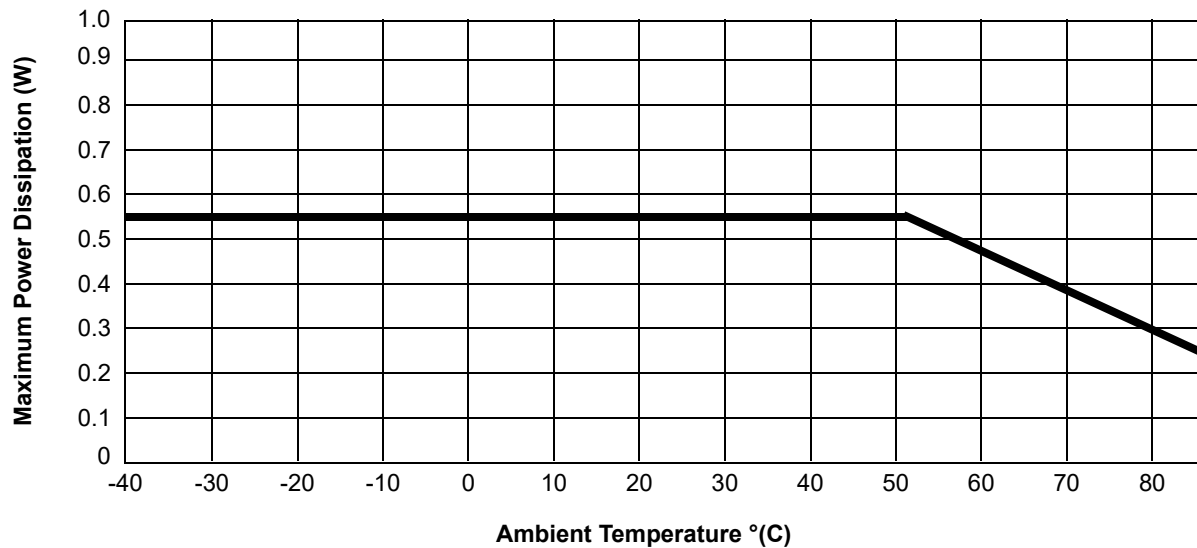
$V_{IN[1,2]}$ = Channel 1 and Channel 2 Input Voltage, in Volts (V), respectively

$R_{LOAD[1,2]}$ = Channel 1 and Channel 2 Output Load Resistance, in Ohms (Ω), respectively

$I_{DS[1,2]}$ = Channel 1 and Channel 2 output current, in Amps (A), respectively

$V_{OUT[1,2]}$ = Channel 1 and Channel 2 output voltage, or $R_{LOAD[1,2]} \times I_{DS[1,2]}$, respectively

Power Dissipation Derating Curve




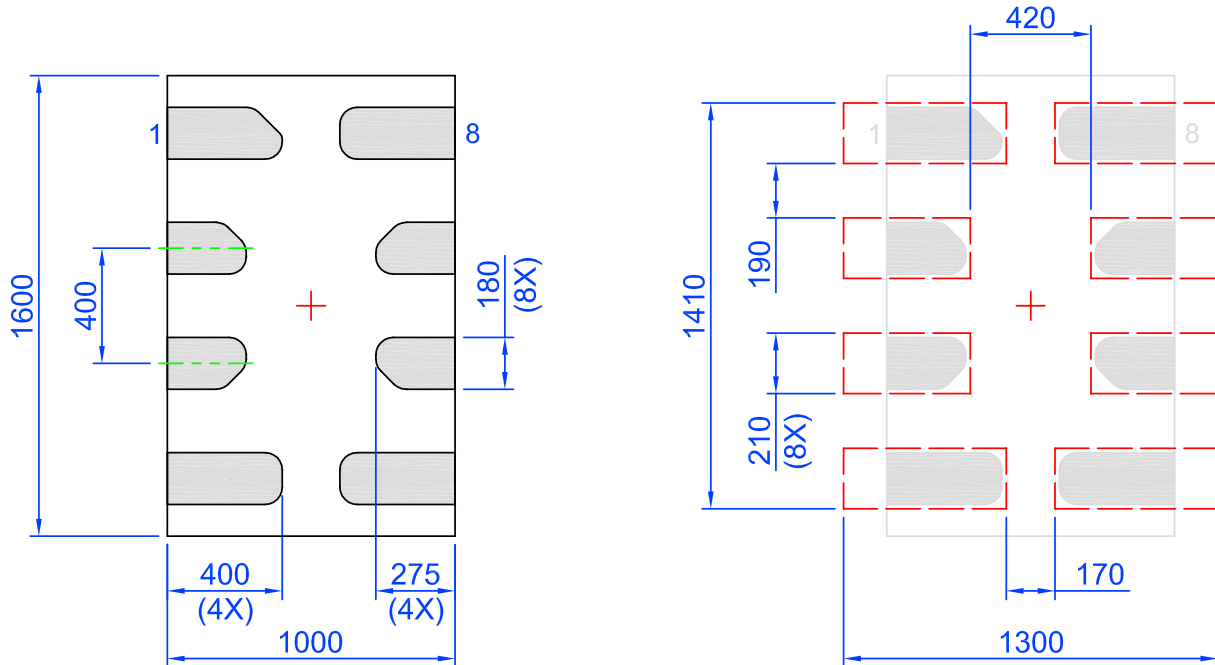
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SLG59M1641V Layout Suggestion

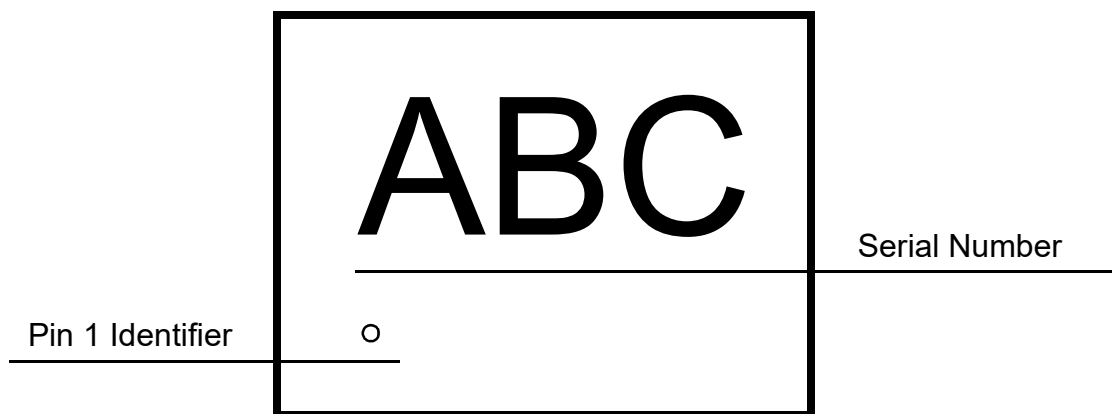
 Exposed Pad
(PKG face down)

 Recommended Land Pattern
(PKG face down)



Note: All dimensions shown in micrometers (μm)

Package Top Marking System Definition



ABC - 3 alphanumeric Part Serial Number
where A, B, or C can be A-Z and 0-9

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Layout Guidelines:

1. Since the VIN[1,2] and VOUT[1,2] pins dissipate most of the heat generated during high-load current operation, it is highly recommended to make power traces as short, direct, and wide as possible. A good practice is to make power traces with an absolute minimum widths of 15 mils (0.381 mm) per Ampere. A representative layout, shown in Figure 1, illustrates proper techniques for heat to transfer as efficiently as possible out of the device;
2. To minimize the effects of parasitic trace inductance on normal operation, it is recommended to connect input C_{IN} and output C_{LOAD} low-ESR capacitors as close as possible to the SLG59M1641V's VIN[1,2] and VOUT[1,2] pins;
3. The GND pin should be connected to system analog or power ground plane.
4. 2 oz. copper is recommended for high current operation.

SLG59M1641V Evaluation Board:

A GreenFET Evaluation Board for SLG59M1641V is designed according to the statements above and is illustrated on Figure 1. Please note that evaluation board has D_Sense and S_Sense pads. They cannot carry high currents and dedicated only for RDS_{ON} evaluation.

Please solder your SLG59M1641V here

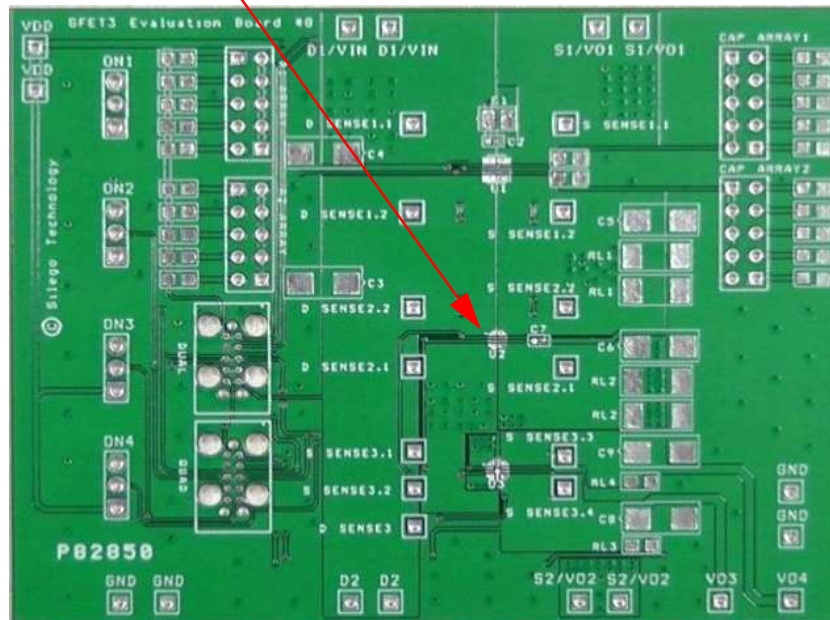


Figure 1. SLG59M1641V Evaluation Board

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Basic Test Setup and Connections

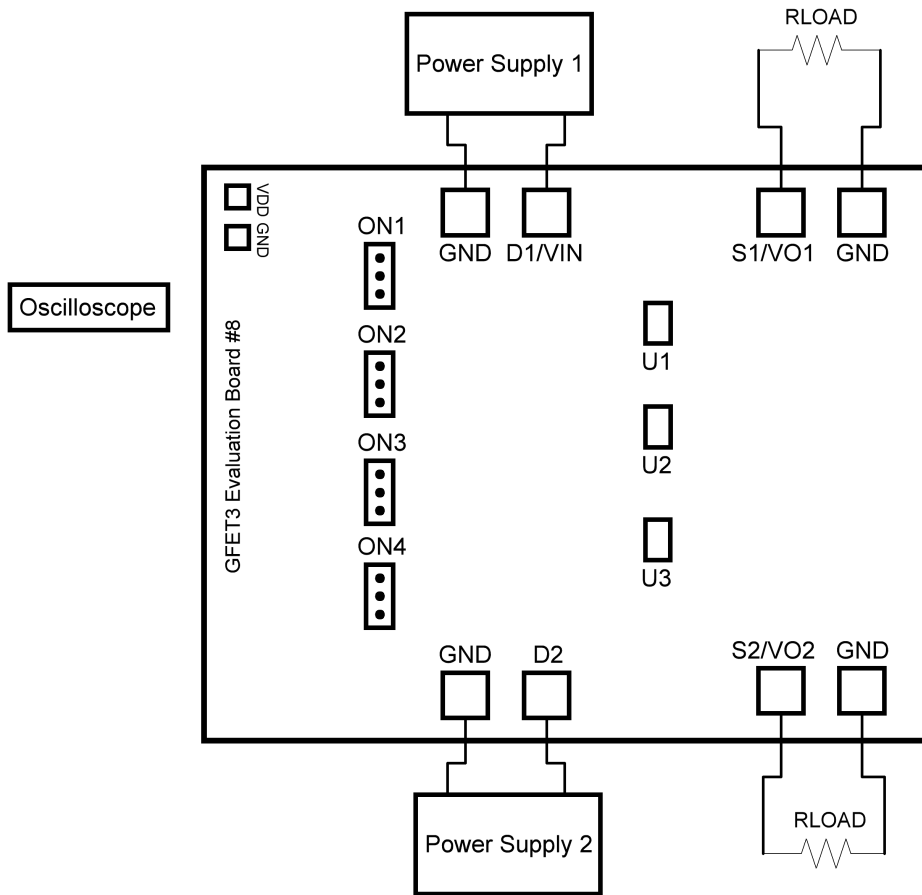


Figure 3. SLG59M1641V Evaluation Board Connection Circuit

EVB Configuration

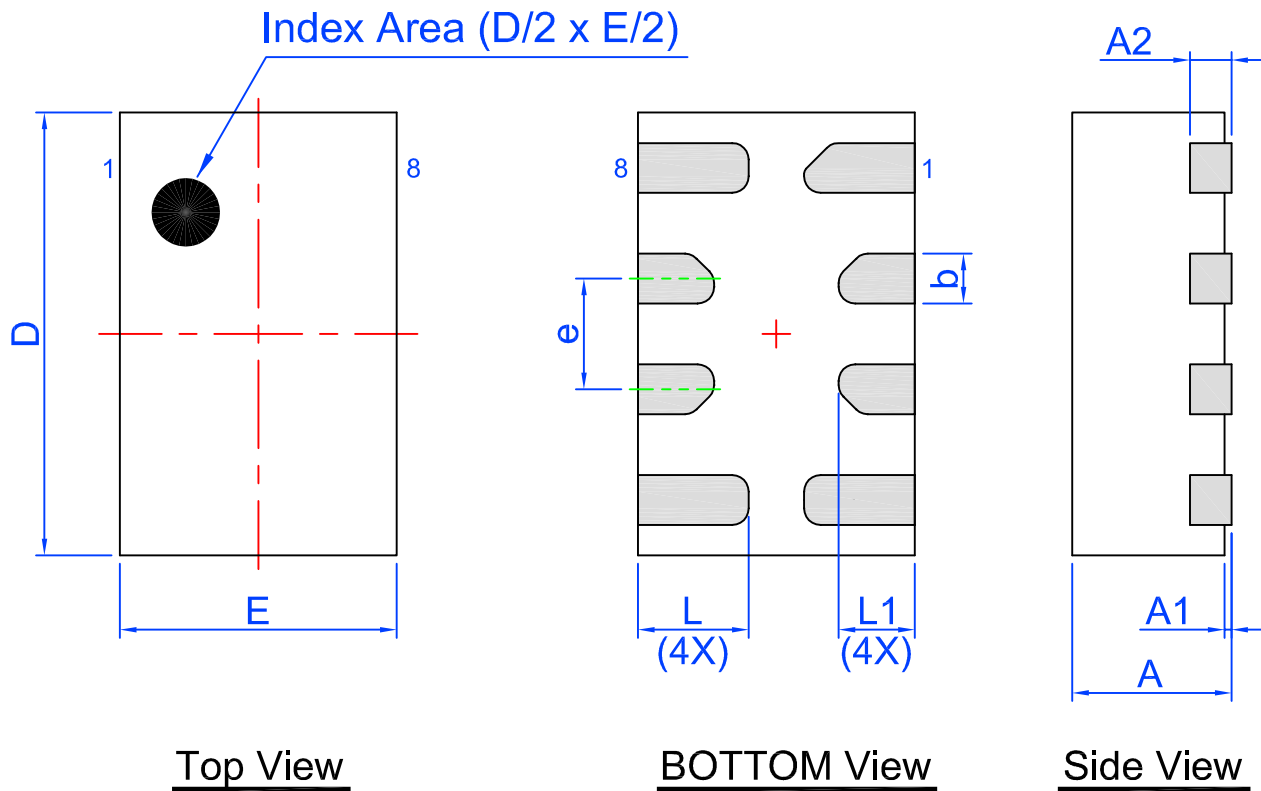
1. Connect oscilloscope probes to D1/VIN, D2, S1/VO1, S2/VO2, ON1, ON2 etc.;
2. Turn on Power Supply 1 and set desired V_{IN1} from 1.5 V...5.5 V range;
3. Turn on Power Supply 2 and set desired V_{IN2} from 1.5 V...5.5 V range;
4. Toggle the ON[1,2] signal High or Low to observe SLG59M1641V operation.

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Package Drawing and Dimensions

8 Lead STDFN Package 1.0 x 1.6 mm



Unit: mm

| Symbol | Min | Nom. | Max | Symbol | Min | Nom. | Max |
|--------|----------|------|-------|--------|-------|-------|-------|
| A | 0.50 | 0.55 | 0.60 | D | 1.55 | 1.60 | 1.65 |
| A1 | 0.005 | - | 0.050 | E | 0.95 | 1.00 | 1.05 |
| A2 | 0.10 | 0.15 | 0.20 | L | 0.35 | 0.40 | 0.45 |
| b | 0.13 | 0.18 | 0.23 | L1 | 0.225 | 0.275 | 0.325 |
| e | 0.40 BSC | | | | | | |

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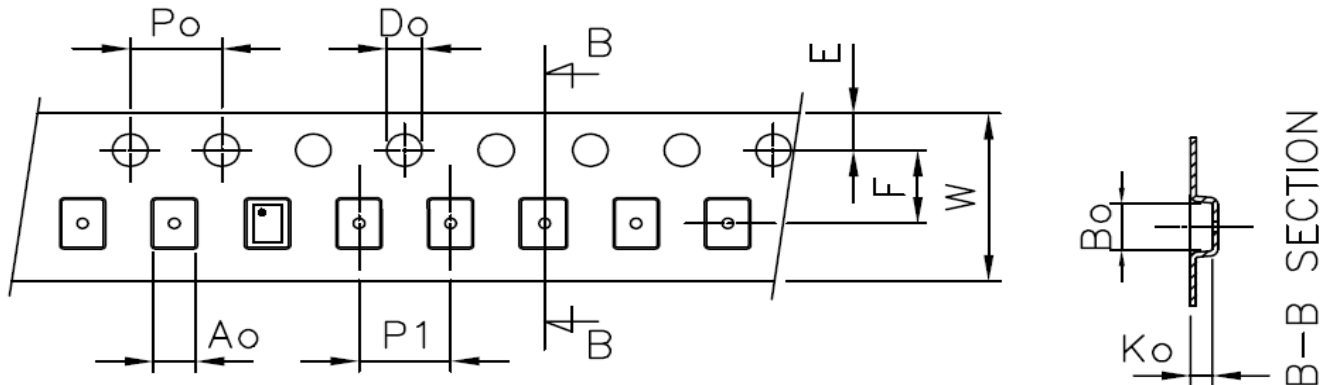
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Tape and Reel Specifications

| Package Type | # of Pins | Nominal Package Size [mm] | Max Units | | Reel & Hub Size [mm] | Leader (min) | | Trailer (min) | | Tape Width [mm] | Part Pitch [mm] |
|--|-----------|---------------------------|-----------|---------|----------------------|--------------|-------------|---------------|-------------|-----------------|-----------------|
| | | | per Reel | per Box | | Pockets | Length [mm] | Pockets | Length [mm] | | |
| STDFN 8L 1x1.6mm 0.4P FCD Green | 8 | 1.0 x 1.6 x 0.55 | 3,000 | 3,000 | 178 / 60 | 100 | 400 | 100 | 400 | 8 | 4 |

Carrier Tape Drawing and Dimensions

| Package Type | Pocket BTM Length | Pocket BTM Width | Pocket Depth | Index Hole Pitch | Pocket Pitch | Index Hole Diameter | Index Hole to Tape Edge | Index Hole to Pocket Center | Tape Width |
|--|-------------------|------------------|--------------|------------------|--------------|---------------------|-------------------------|-----------------------------|------------|
| | A0 | B0 | K0 | P0 | P1 | D0 | E | F | W |
| STDFN 8L 1x1.6mm 0.4P FCD Green | 1.12 | 1.72 | 0.7 | 4 | 4 | 1.55 | 1.75 | 3.5 | 8 |



Recommended Reflow Soldering Profile

Please see IPC/JEDEC J-STD-020: latest revision for reflow profile based on package volume of 0.88 mm³ (nominal). More information can be found at www.jedec.org.

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Revision History

| Date | Version | Change |
|------------|---------|---|
| 2/7/2022 | 1.09 | Updated Company name and logo Fixed typos |
| 4/2/2018 | 1.08 | Updated Electrical Characteristics |
| 12/10/2018 | 1.07 | Updated style and formatting Updated Charts Added Layout Guidelines |
| 8/28/2017 | 1.06 | Updated Inrush Current Details Fixed typos |
| 4/13/2017 | 1.05 | Fixed Reverse Voltage Detection equation |
| 6/29/2016 | 1.04 | Updated T_{REARM} |
| 4/4/2016 | 1.03 | Updated Electrical Characteristics |
| 2/17/2016 | 1.02 | Updated POD and Landing Pattern |
| 2/9/2016 | 1.01 | Updated Electrical Characteristics |
| 2/3/2016 | 1.00 | Production Release |

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