

# SLG59H1010V

## A 13.3 mΩ, 5 A Load Switch with 12 V / 24 V $V_{IN}$ Lockout Select and MOSFET Current Monitor Output

### General Description

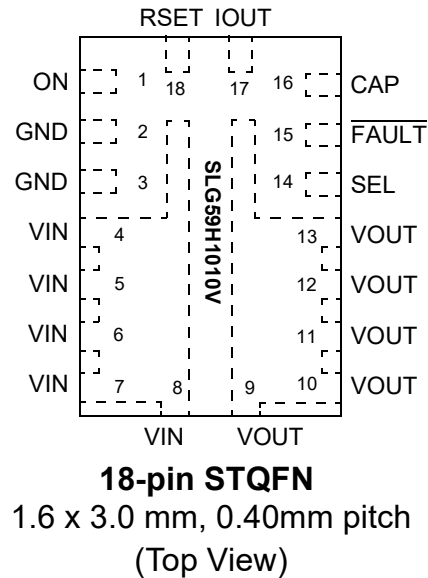
The SLG59H1010V is a high-performance 13.3 mΩ NMOS load switch designed to control 12 V or 24 V power rails up to 5 A. Using a proprietary MOSFET design, the SLG59H1010V achieves a stable 13.3 mΩ  $R_{DS(ON)}$  across a wide input voltage range. In combining novel FET design and copper pillar interconnects, the SLG59H1010V package also exhibits a low thermal resistance for high-current operation.

Designed to operate over a -40 °C to 85 °C range, the SLG59H1010V is available in a low thermal resistance, RoHS-compliant, 1.6 x 3.0 mm STQFN package.

### Features

- Wide Operating Input Voltage: 12 V or 24 V
- Maximum Continuous Current: 5 A
- Automatic nFET SOA Protection
  - 5 W SOA Protection Threshold
- High-performance MOSFET Switch
  - Low  $R_{DS(ON)}$ : 13.3 mΩ at  $V_{IN} = 24$  V
  - Low  $\Delta R_{DS(ON)}/\Delta V_{IN}$ : < 0.05 mΩ/V
  - Low  $\Delta R_{DS(ON)}/\Delta T$ : < 0.06 mΩ/°C
- Pin-selectable 12V/24V Input Overvoltage and Undervoltage Lockout
- Capacitor-adjustable Inrush Current Control
- Two stage Current Limit Protection:
  - Resistor-adjustable Active Current Limit
  - Internal Short-circuit Current limit
- Open Drain  $\overline{FAULT}$  Signaling
- MOSFET Current Analog Output Monitor: 10  $\mu$ A/A
- Fast 4 kΩ Output Discharge
  - Pb-Free / Halogen-Free / RoHS Compliant Packaging

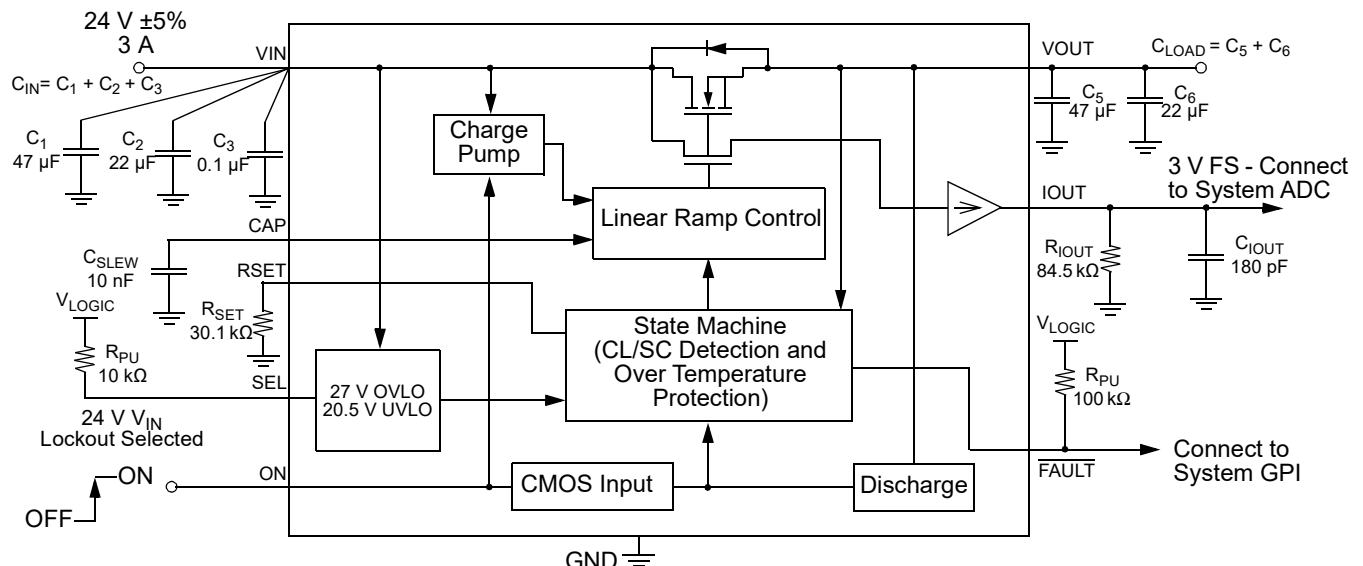
### Pin Configuration



### Applications

- Power-Rail Switching
- Multifunction Printers
- Large-format Copiers
- Telecommunications Equipment
- High-performance Computing
- 12 V and 24 V Point-of-Load Power Distribution
- Motor Drives

### Block Diagram and 3 A Typical Application Circuit



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### Pin Description

| Pin # | Pin Name                  | Type   | Pin Description  |
|-------|---------------------------|--------|--|
| 1     | ON                        | Input  | A low-to-high transition on this pin initiates the operation of the SLG59H1010V's state machine. ON is an asserted HIGH, level-sensitive CMOS input with $ON_{V_{IL}} < 0.3\text{ V}$ and $ON_{V_{IH}} > 0.9\text{ V}$ . As the ON pin input circuit does not have an internal pull-down resistor, connect this pin to a general-purpose output (GPO) of a microcontroller, an application processor, or a system controller, do not allow this pin to be open-circuited.  |
| 2     | GND                       | GND    | Pin 2 is a low-current GND terminal for the SLG59H1010V. Connect directly to Pin 3.  |
| 3     | GND                       | GND    | Pin 3 is the main ground connection for the SLG59H1010V's internal charge pump, its gate driver and current-limit circuits as well as its internal state machine. Therefore, use a short, stout connection from Pin 3 to the system's analog or power plane.   |
| 4-8   | VIN                       | MOSFET | VIN supplies the power for the operation of the SLG59H1010V, its internal control circuitry, and the drain terminal of the nFET load switch. With 5 pins fused together at VIN, connect a 47 μF (or larger) low-ESR capacitor from this pin to ground. Capacitors used at VIN should be rated at 50 V or higher.   |
| 9-13  | VOUT                      | MOSFET | Source terminal of n-channel MOSFET (5 pins fused for VOUT). Connect a 47 μF (or larger) low-ESR capacitor from this pin to ground. Capacitors used at VOUT should be rated at 50 V or higher.   |
| 14    | SEL                       | Input  | As a low logic-level CMOS input with $SEL_{V_{IL}} < 0.3\text{ V}$ and $SEL_{V_{IH}} > 1.65\text{ V}$ , SEL selects one of two undervoltage/overvoltage lockout windows. When SEL = LOW, the $V_{IN}$ undervoltage/overvoltage lockout window is set for 12 V ±10% applications. When SEL = HIGH, the $V_{IN}$ undervoltage/overvoltage lockout window is set for 24 V ± 5% applications. See the Electrical Characteristics table for additional information.   |
| 15    | $\overline{\text{FAULT}}$ | Output | An open drain output, $\overline{\text{FAULT}}$ is asserted within $T_{\overline{\text{FAULT}}_{\text{LOW}}}$ when a $V_{IN}$ undervoltage, $V_{IN}$ overvoltage, a current-limit, or an over-temperature condition is detected. $\overline{\text{FAULT}}$ is deasserted within $T_{\overline{\text{FAULT}}_{\text{HIGH}}}$ when the fault condition is removed. Connect an 100 kΩ external resistor from the $\overline{\text{FAULT}}$ pin to local system logic supply.  |
| 16    | CAP                       | Output | A low-ESR, stable dielectric, ceramic surface-mount capacitor connected from CAP pin to GND sets the $V_{\text{OUT}}$ slew rate and overall turn-on time of the SLG59H1010V. For best performance, the range for $C_{\text{SLEW}}$ values are $10\text{ nF} \leq C_{\text{SLEW}} \leq 20\text{ nF}$ – please see typical characteristics for additional information. Capacitors used at the CAP pin should be rated at 10 V or higher. Please consult Applications Section on how to select $C_{\text{SLEW}}$ based on $V_{\text{OUT}}$ slew rate and loading conditions.                        |
| 17    | IOUT                      | Output | IOUT is the SLG59H1010V's power MOSFET load current monitor output. As an analog current output, this signal when applied to a ground-reference resistor generates a voltage proportional to the current through the n-channel MOSFET. The $I_{\text{OUT}}$ transfer characteristic is typically 10 μA/A with a voltage compliance range of $0.5\text{ V} \leq V_{\text{IOUT}} \leq 4\text{ V}$ . Optimal $I_{\text{OUT}}$ linearity is exhibited for $0.5\text{ A} \leq I_{\text{DS}} \leq 5\text{ A}$ . In addition, it is recommended to bypass the IOUT pin to GND with a 0.18 nF capacitor. |
| 18    | RSET                      | Input  | A 1%-tolerance, metal-film resistor between 18 kΩ and 91 kΩ sets the SLG59H1010V's active current limit. A 91 kΩ resistor sets the SLG59H1010V's active current limit to 1 A and a 18 kΩ resistor sets the active current limit to 5 A.  |

### Ordering Information

| Part Number   | Type                         | Production Flow             |
|---------------|------------------------------|-----------------------------|
| SLG59H1010V   | STQFN 18L FC                 | Industrial, -40 °C to 85 °C |
| SLG59H1010VTR | STQFN 18L FC (Tape and Reel) | Industrial, -40 °C to 85 °C |

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### Absolute Maximum Ratings

| Parameter                                  | Description   | Conditions  | Min. | Typ. | Max.     | Unit |
|--|---|---|------|------|----------|------|
| $V_{IN}$ to GND                            | Load Switch Input Voltage to GND                        | Continuous  | -0.3 | --   | 30       | V    |
|  |   | Maximum pulsed $V_{IN}$ , pulse width < 0.1 s   | --   | --   | 32       | V    |
| $V_{OUT}$ to GND                           | Load Switch Output Voltage to GND                       |   | -0.3 | --   | $V_{IN}$ | V    |
| ON, SEL, CAP, RSET, IOUT, and FAULT to GND | ON, SEL, CAP, RSET, IOUT, and FAULT Pin Voltages to GND |   | -0.3 | --   | 7        | V    |
| $T_S$                                      | Storage Temperature                                     |   | -65  | --   | 150      | °C   |
| ESD <sub>HBM</sub>                         | ESD Protection  | Human Body Model  | 2000 | --   | --       | V    |
| ESD <sub>CDM</sub>                         | ESD Protection  | Charged Device Model  | 500  | --   | --       | V    |
| MSL  | Moisture Sensitivity Level                              |   | 1    |      |          |      |
| $\theta_{JA}$                              | Thermal Resistance                                      | 1.6 x 3.0 mm 18L STQFN; Determined with the device mounted onto a 1 in <sup>2</sup> , 1 oz. copper pad of FR-4 material | --   | 40   | --       | °C/W |
| MOSFET IDS <sub>CONT</sub>                 | Continuous Current from VIN to VOUT                     | $T_J < 150\text{ °C}$   | --   | --   | 5        | A    |
| MOSFET IDS <sub>PEAK</sub>                 | Peak Current from VIN to VOUT                           | Maximum pulsed switch current, pulse width < 1 ms   | --   | --   | 6        | 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

12 V ≤  $V_{IN}$  ≤ 24 V;  $C_{IN}$  = 47 μF,  $T_A$  = -40 °C to 85 °C, unless otherwise noted. Typical values are at  $T_A$  = 25 °C

| Parameter            | Description                             | Conditions   | Min. | Typ. | Max. | Unit |
|----------------------|---|--|------|------|------|------|
| $V_{IN}$             | Operating Input Voltage                 |  | 10.8 | --   | 25.2 | V    |
| $V_{IN(OVLO)}$       | $V_{IN}$ Overvoltage Lockout Threshold  | $V_{IN} \uparrow$ ; SEL = HIGH                             | 25.3 | 27   | 28.5 | V    |
|                      |   | $V_{IN} \uparrow$ ; SEL = LOW                              | 13.3 | 13.7 | 14.5 | V    |
| $V_{IN(UVLO)}$       | $V_{IN}$ Undervoltage Lockout Threshold | $V_{IN} \downarrow$ ; SEL = HIGH                           | 19.5 | 20.5 | 21.5 | V    |
|                      |   | $V_{IN} \downarrow$ ; SEL = LOW                            | 9.7  | 10.2 | 10.7 | V    |
| $I_Q$                | Quiescent Supply Current                | ON = HIGH; $I_{DS} = 0\text{ A}$                           | --   | 0.5  | 0.6  | mA   |
| $I_{SHDN}$           | OFF Mode Supply Current                 | ON = LOW; $I_{DS} = 0\text{ A}$                            | --   | 1    | 3    | μA   |
| RDS <sub>ON</sub>    | ON Resistance                           | $T_A = 25\text{ °C}$ ; $I_{DS} = 0.1\text{ A}$             | --   | 13.3 | 14.5 | mΩ   |
|                      |   | $T_A = 85\text{ °C}$ ; $I_{DS} = 0.1\text{ A}$             | --   | 17.2 | 18   | mΩ   |
| MOSFET IDS           | Current from VIN to VOUT                | Continuous   | --   | --   | 5    | A    |
| $I_{LIMIT}$          | Active Current Limit, $I_{ACL}$         | $V_{OUT} > 0.5\text{ V}$ ; $R_{SET} = 30.1\text{ k}\Omega$ | 3.0  | 3.19 | 3.5  | A    |
|                      | Short-circuit Current Limit, $I_{SCL}$  | $V_{OUT} < 0.5\text{ V}$                                   | --   | 0.5  | -    | A    |
| $T_{ACL}$            | Active Current Limit Response Time      | $R_{SET} = 51.6\text{ k}\Omega$                            | --   | 120  | --   | μs   |
| R <sub>DISCHRG</sub> | Output Discharge Resistance             |  | 3.5  | 4.4  | 5.3  | kΩ   |
| $I_{OUT}$            | MOSFET Current Analog Monitor Output    | $I_{DS} = 1\text{ A}$                                      | 9.3  | 10   | 10.9 | μA   |
|                      |   | $I_{DS} = 3\text{ A}$                                      | 28.5 | 30   | 31.7 | μA   |

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### Electrical Characteristics (continued)

12 V ≤ V<sub>IN</sub> ≤ 24 V; C<sub>IN</sub> = 47 μF, T<sub>A</sub> = -40 °C to 85 °C, unless otherwise noted. Typical values are at T<sub>A</sub> = 25 °C

| Parameter                | Description   | Conditions  | Min.   | Typ. | Max. | Unit |
|--------------------------|---|---|--|------|------|------|
| T <sub>IOUT</sub>        | I <sub>OUT</sub> Response Time to Change in Main MOSFET Current | C <sub>IOUT</sub> = 180 pF;<br>Step load 0 to 2.4 A; 0% to 90% I <sub>OUT</sub>   | --   | 45   | --   | μs   |
| C <sub>LOAD</sub>        | Output Load Capacitance   | C <sub>LOAD</sub> connected from V <sub>OUT</sub> to GND  | --   | 47   | --   | μF   |
| T <sub>ON_Delay</sub>    | ON Delay Time   | 50% ON to 10% V <sub>OUT</sub> ↑;<br>V <sub>IN</sub> = 12 V; C <sub>SLEW</sub> = 10 nF;<br>R <sub>LOAD</sub> = 100 Ω, C <sub>LOAD</sub> = 10 μF                       | 480  | 600  | 720  | μs   |
|                          |   | 50% ON to 10% V <sub>OUT</sub> ↑;<br>V <sub>IN</sub> = 24 V; C <sub>SLEW</sub> = 10 nF;<br>R <sub>LOAD</sub> = 100 Ω, C <sub>LOAD</sub> = 10 μF                       | 0.8  | 1.0  | 1.2  | ms   |
| T <sub>Total_ON</sub>    | Total Turn ON Time  | 50% ON to 90% V <sub>OUT</sub> ↑  | Set by External C <sub>SLEW</sub> <sup>1</sup> |      |      | ms   |
|                          |   | 50% ON to 90% V <sub>OUT</sub> ↑;<br>V <sub>IN</sub> = 12 V; C <sub>SLEW</sub> = 10 nF;<br>R <sub>LOAD</sub> = 100 Ω, C <sub>LOAD</sub> = 10 μF                       | 2.9  | 3.6  | 4.3  | ms   |
|                          |   | 50% ON to 90% V <sub>OUT</sub> ↑;<br>V <sub>IN</sub> = 24 V; C <sub>SLEW</sub> = 10 nF;<br>R <sub>LOAD</sub> = 100 Ω, C <sub>LOAD</sub> = 10 μF                       | 5.7  | 7.1  | 8.5  | ms   |
| V <sub>OUT(SR)</sub>     | V <sub>OUT</sub> Slew rate                                      | 10% V <sub>OUT</sub> to 90% V <sub>OUT</sub> ↑  | Set by External C <sub>SLEW</sub> <sup>1</sup> |      |      | V/ms |
|                          |   | 10% V <sub>OUT</sub> to 90% V <sub>OUT</sub> ↑;<br>V <sub>IN</sub> = 12 V or 24 V; C <sub>SLEW</sub> = 10 nF;<br>R <sub>LOAD</sub> = 100 Ω, C <sub>LOAD</sub> = 10 μF | 2.7  | 3.2  | 3.9  | V/ms |
| T <sub>OFF_Delay</sub>   | OFF Delay Time  | 50% ON to V <sub>OUT</sub> Fall Start ↓;<br>V <sub>IN</sub> = 12 V or 24 V;<br>R <sub>LOAD</sub> = 100 Ω, No C <sub>LOAD</sub>  | --   | 15   | --   | μs   |
| T <sub>FALL</sub>        | V <sub>OUT</sub> Fall Time                                      | 90% V <sub>OUT</sub> to 10% V <sub>OUT</sub> ;<br>ON = HIGH-to-LOW;<br>V <sub>IN</sub> = 12 V or 24 V;<br>R <sub>LOAD</sub> = 100 Ω, No C <sub>LOAD</sub>             | 10.4   | 12.7 | 15   | μs   |
| T <sub>FAULT_LOW</sub>   | FAULT Assertion Time  | Abnormal Step Load Current event to<br>FAULT ↓; I <sub>ACL</sub> = 1 A; V <sub>IN</sub> = 24 V;<br>R <sub>SET</sub> = 91 kΩ; switch in 20 Ω load                      | --   | 80   | --   | μs   |
| T <sub>FAULT_HIGH</sub>  | FAULT De-assertion Time   | Delay to FAULT ↑ after fault condition<br>is removed; I <sub>ACL</sub> = 1 A; V <sub>IN</sub> = 24 V;<br>R <sub>SET</sub> = 91 kΩ; switch out 20 Ω load               | --   | 180  | --   | μs   |
| FAULT <sub>VOL</sub>     | FAULT Output Low Voltage  | I <sub>FAULT</sub> = 1 mA   | --   | 0.2  | --   | V    |
| ON_V <sub>IH</sub>       | ON Pin Input High Voltage                                       |   | 0.9  | --   | 5    | V    |
| ON_V <sub>IL</sub>       | ON Pin Input Low Voltage  |   | -0.3   | 0    | 0.3  | V    |
| SEL_V <sub>IH</sub>      | SEL pin Input High Voltage                                      |   | 1.65   | --   | 4.5  | V    |
| SEL_V <sub>IL</sub>      | SEL pin Input Low Voltage                                       |   | -0.3   | --   | 0.3  | V    |
| I <sub>ON(Leakage)</sub> | ON Pin Leakage Current  | 1 V ≤ ON ≤ 5 V or ON = GND  | --   | --   | 1    | μA   |
| THERM <sub>ON</sub>      | Thermal Protection Shutdown Threshold                           |   | --   | 125  | --   | °C   |
| THERM <sub>OFF</sub>     | Thermal Protection Restart Threshold                            |   | --   | 100  | --   | °C   |

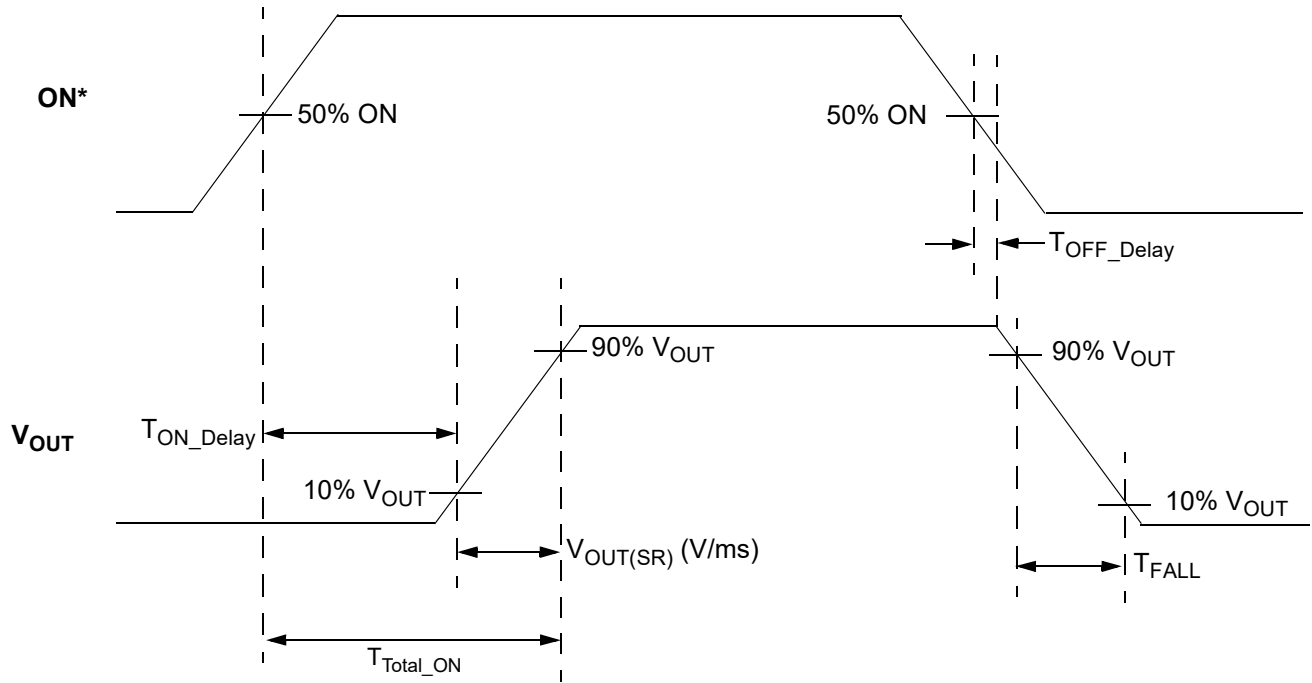
Notes:

1. Refer to typical Timing Parameter vs. C<sub>SLEW</sub> performance charts for additional information.

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A 13.3 mΩ, 5 A Load Switch with 12 V / 24 V  
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$T_{Total\_ON}$ ,  $T_{ON\_Delay}$  and Slew Rate Measurement



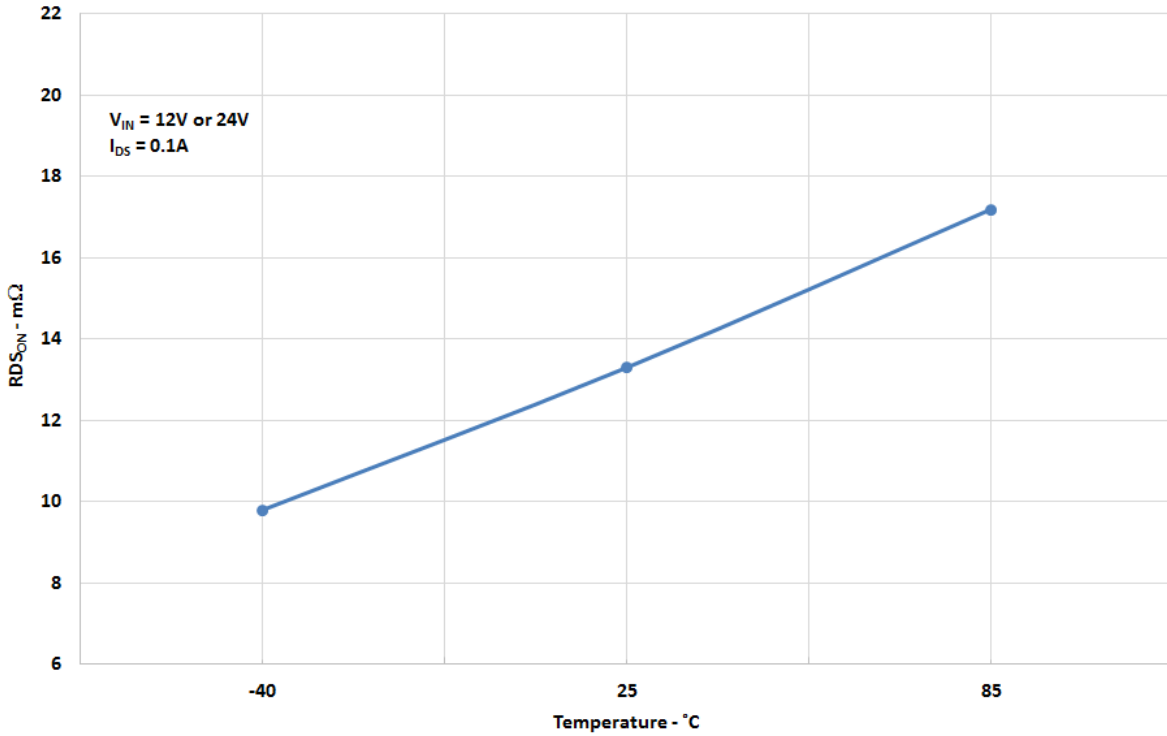
\*Rise and Fall Times of the ON Signal are 100 ns

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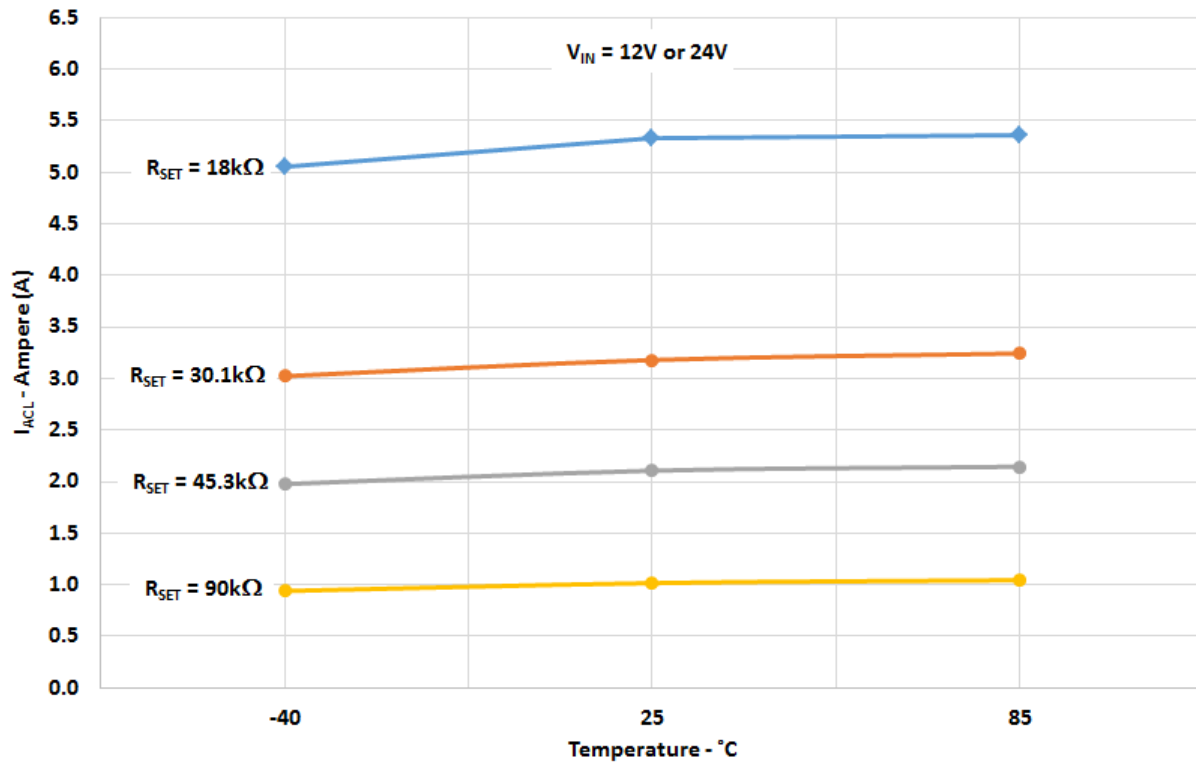
A 13.3 mΩ, 5 A Load Switch with 12 V / 24 V  
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## Typical Performance Characteristics

### $R_{DS(ON)}$ vs. Temperature and $V_{IN}$



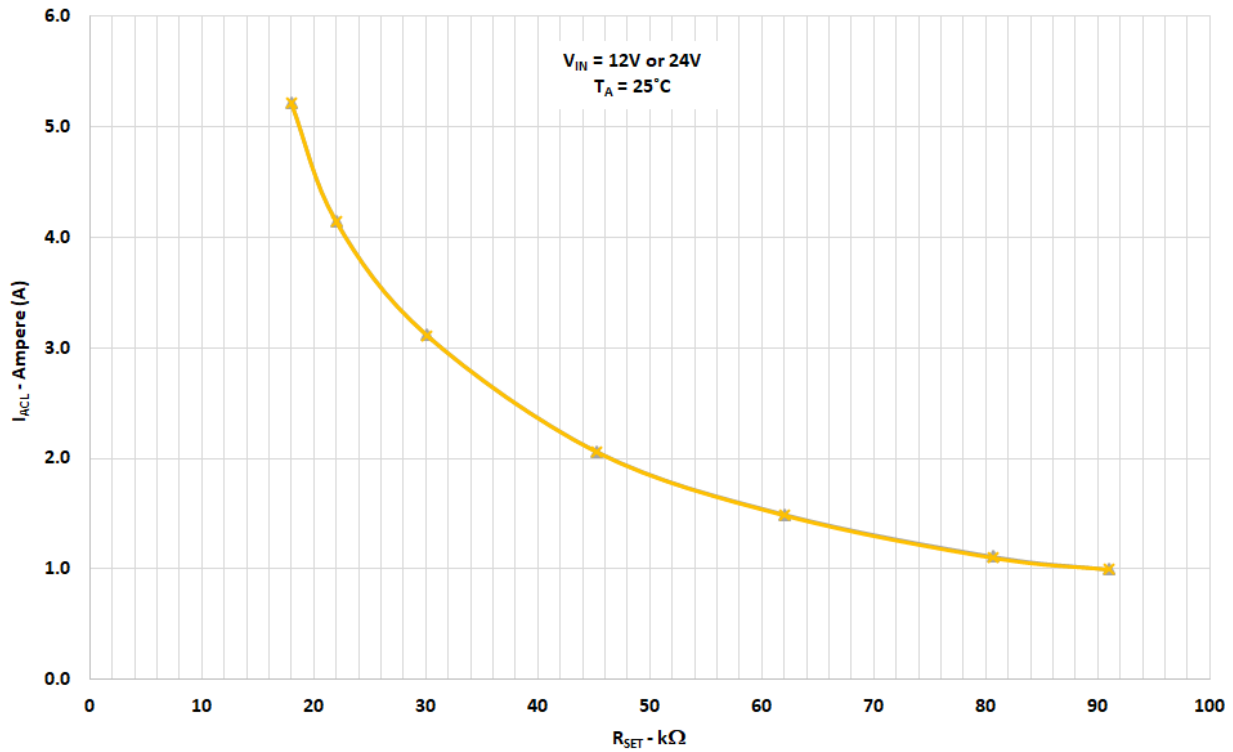
### $I_{ACL}$ vs. Temperature and $R_{SET}$



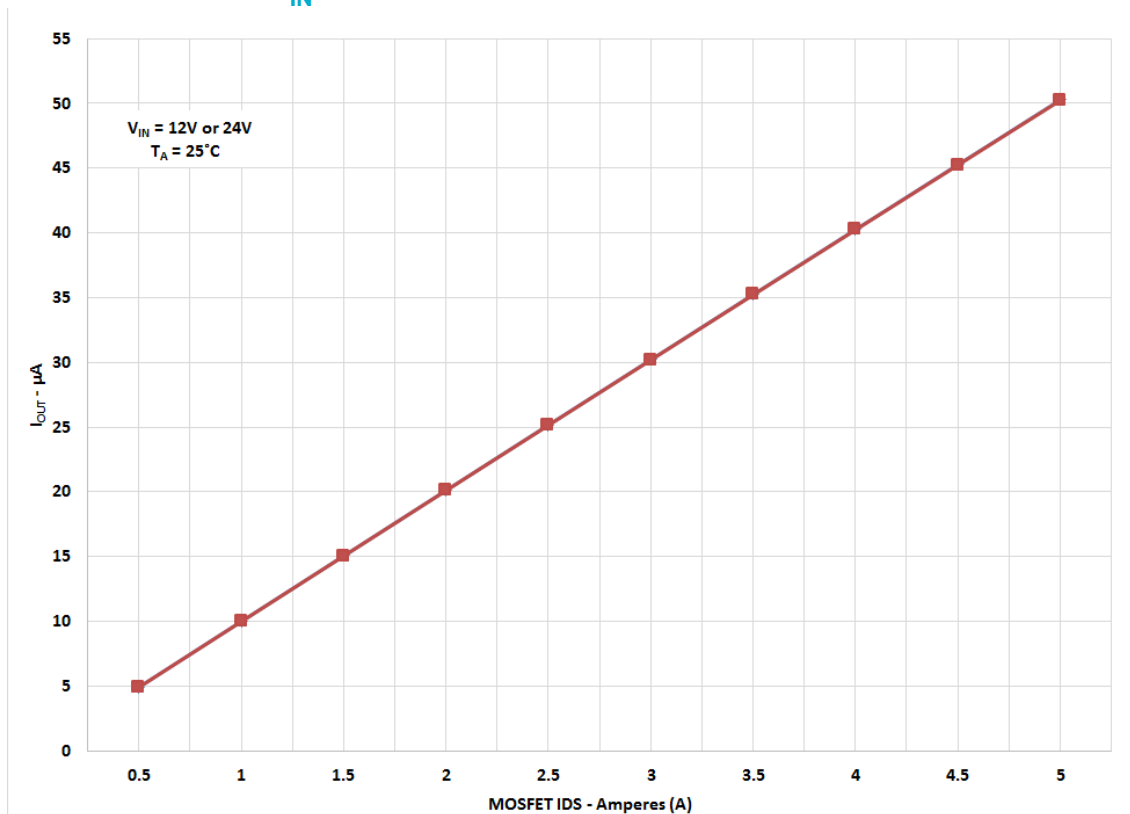
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## $I_{ACL}$ vs. $R_{SET}$ and $V_{IN}$



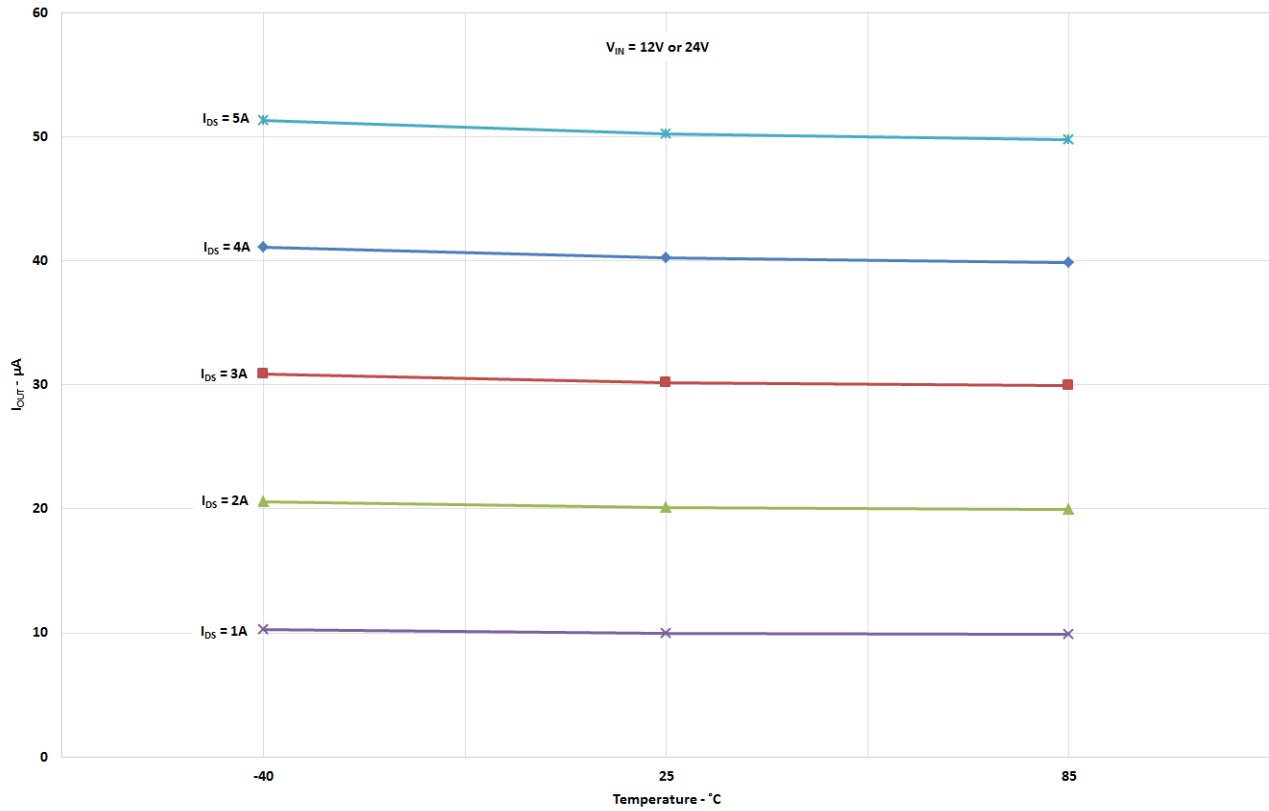
## $I_{OUT}$ vs. MOSFET $I_{DS}$ and $V_{IN}$



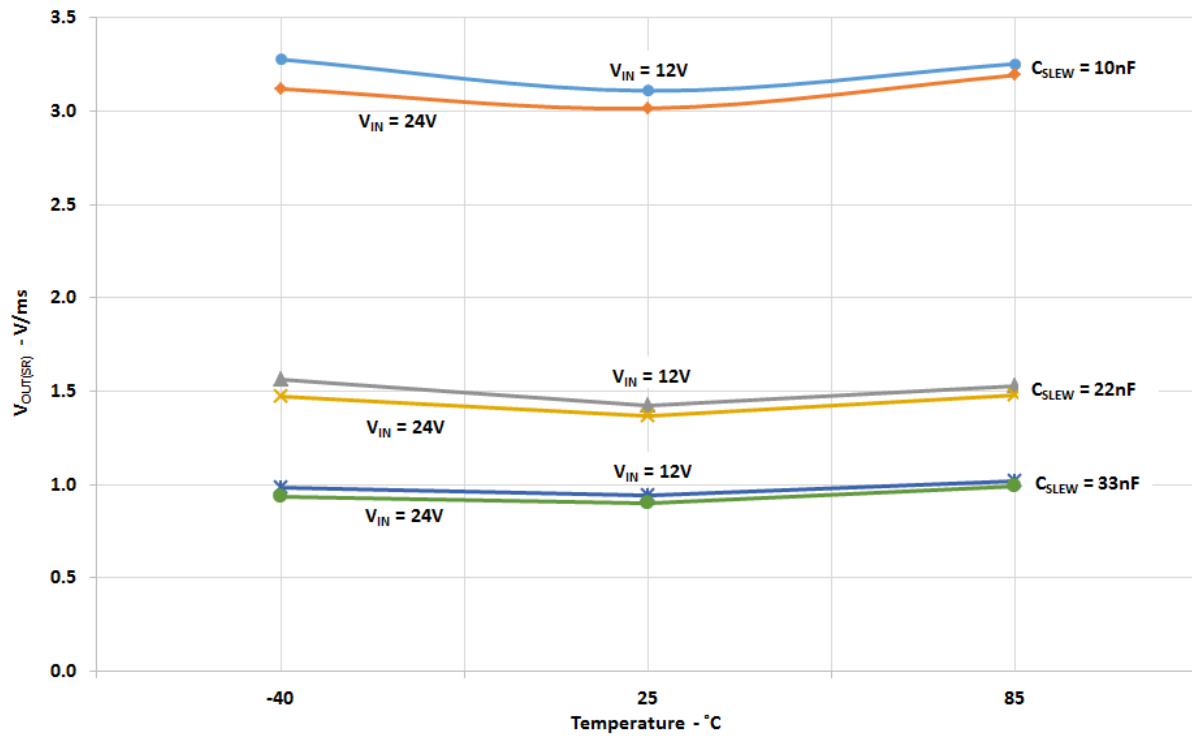
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A 13.3 mΩ, 5 A Load Switch with 12 V / 24 V  
 $V_{IN}$  Lockout Select and MOSFET Current Monitor Output

## $I_{OUT}$ vs. Temperature and MOSFET $I_{DS}$



## $V_{OUT}$ Slew Rate vs. Temperature, $V_{IN}$ , and $C_{SLEW}$

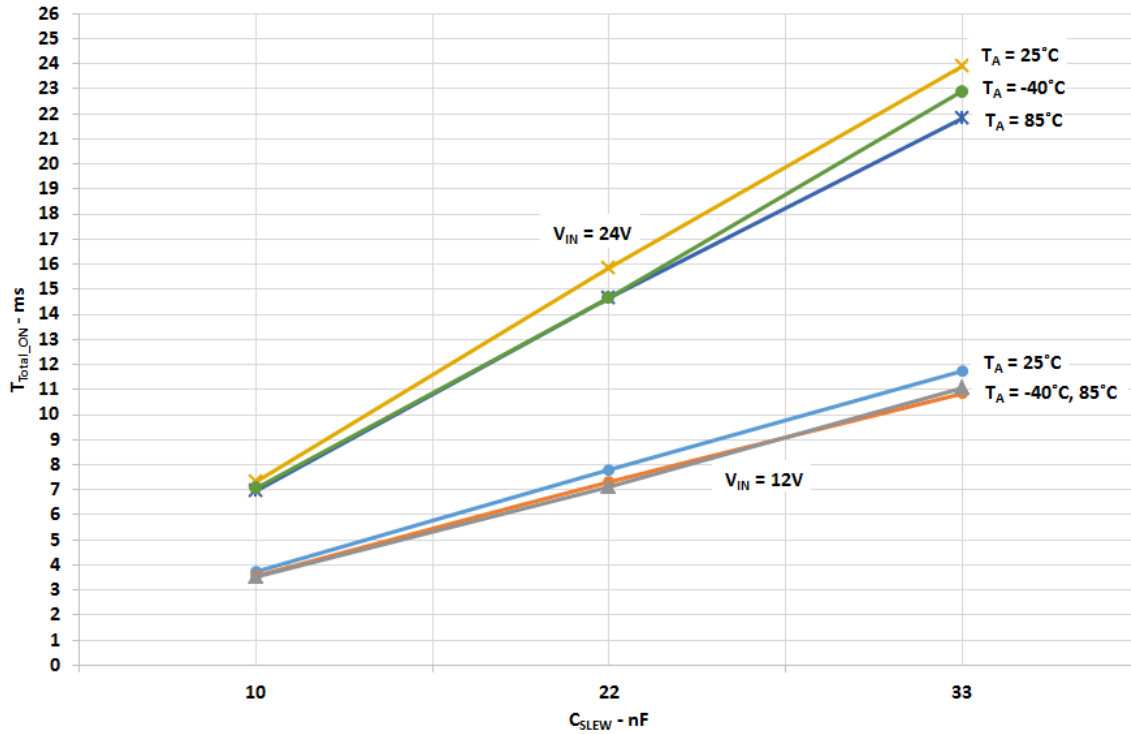




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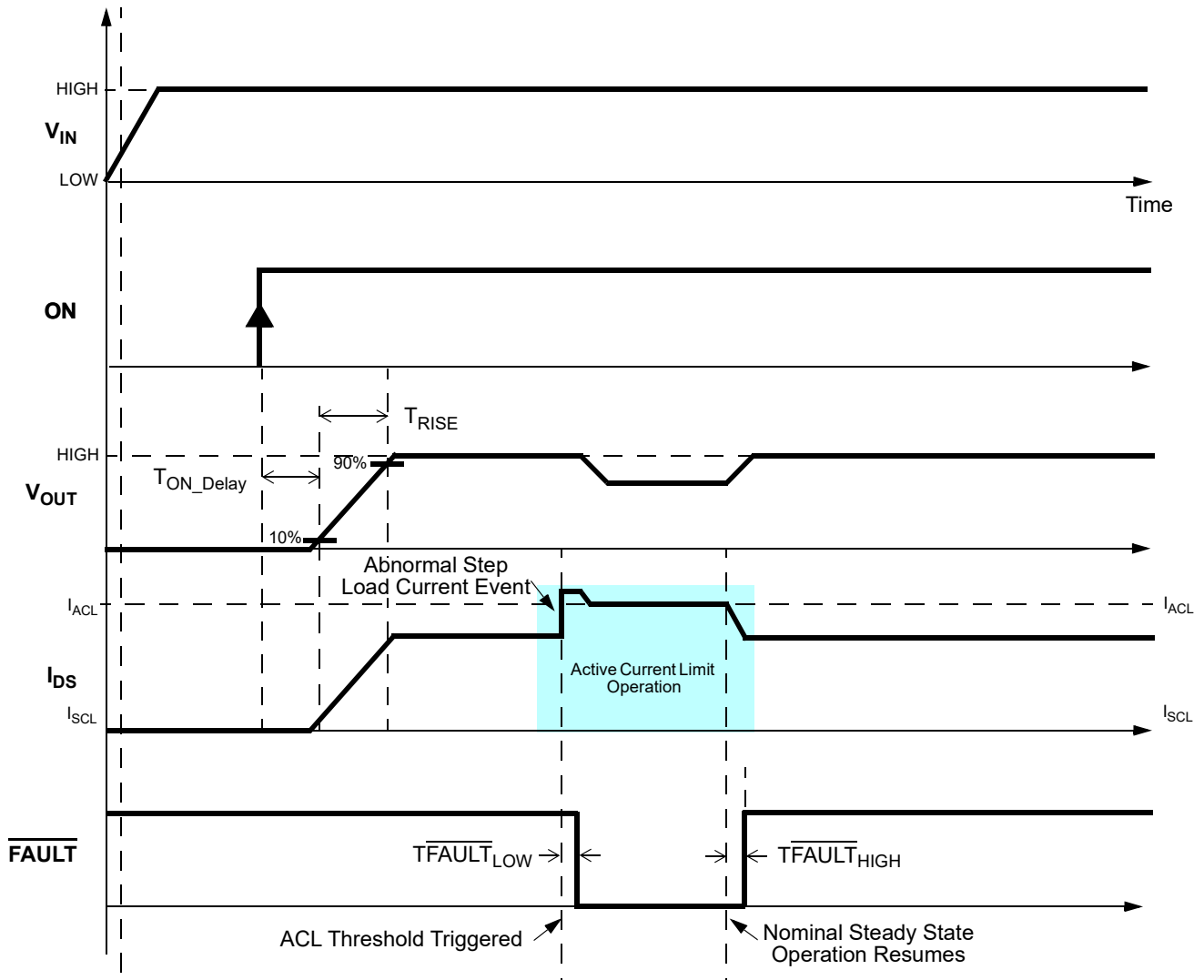
$T_{Total\_ON}$  vs.  $C_{SLEW}$ ,  $V_{IN}$ , and Temperature



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A 13.3 mΩ, 5 A Load Switch with 12 V / 24 V  
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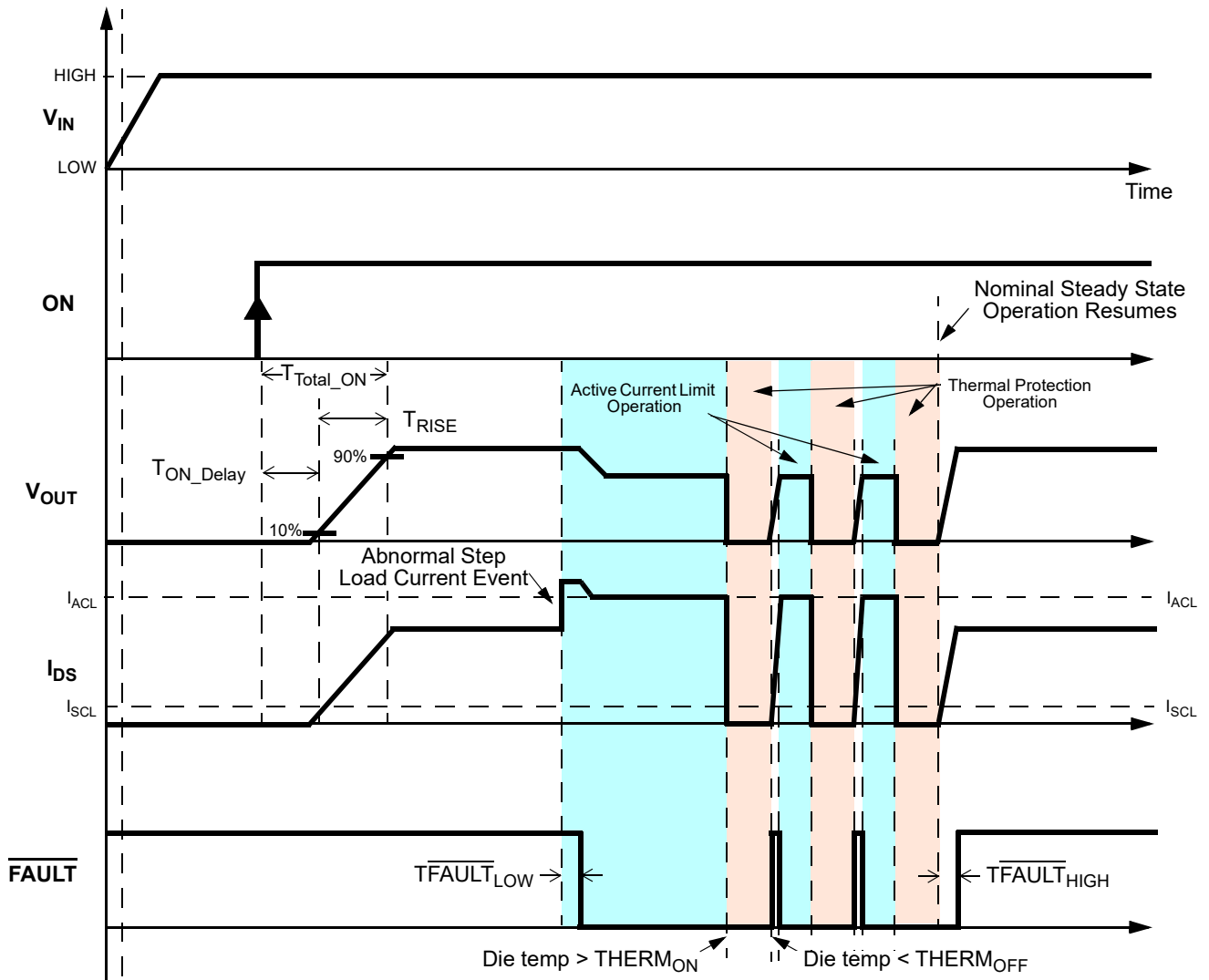
Timing Diagram - Basic Operation including Active Current Limit Protection



SLG59H1010V

A 13.3 mΩ, 5 A Load Switch with 12 V / 24 V  
 $V_{IN}$  Lockout Select and MOSFET Current Monitor Output

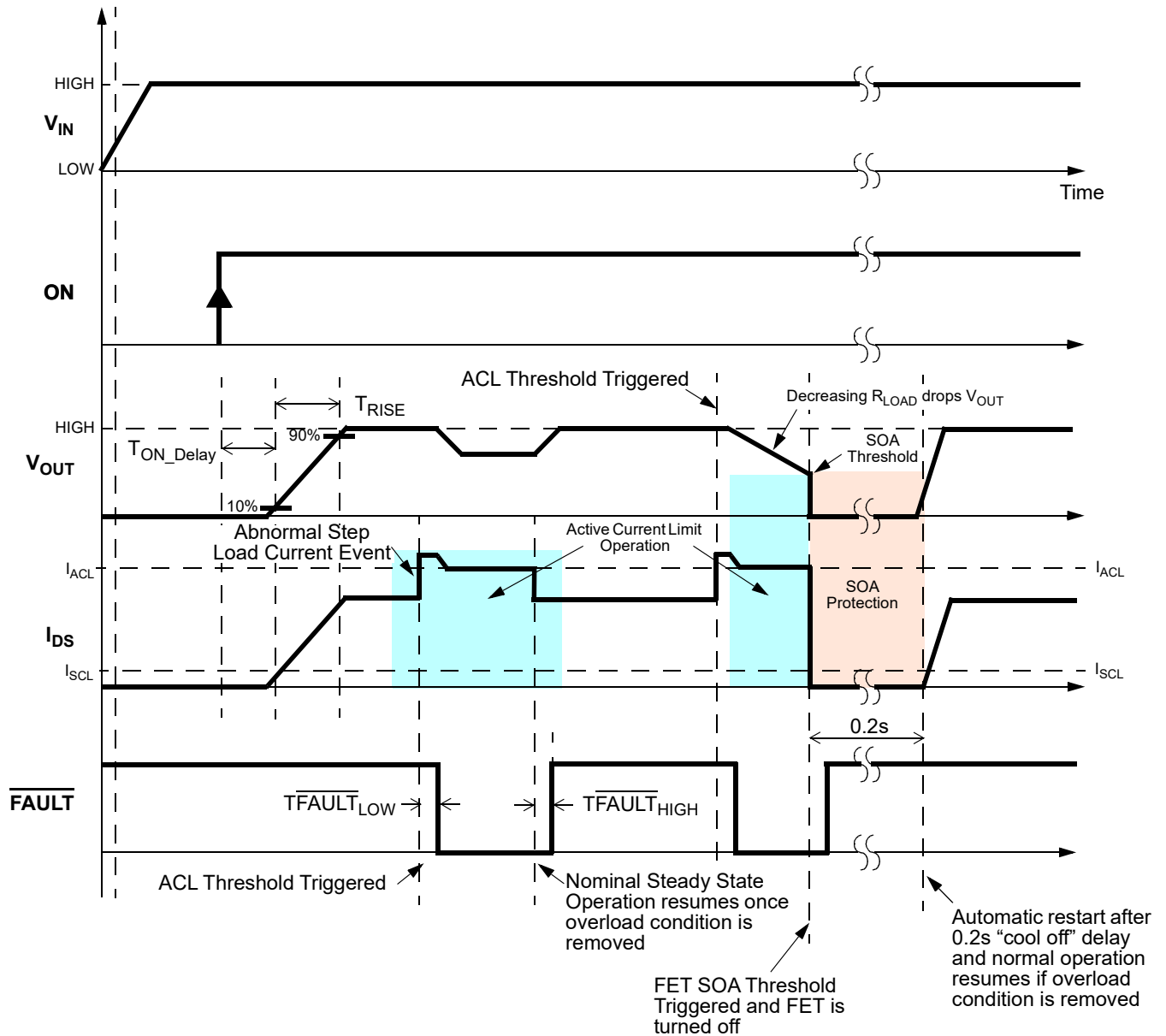
Timing Diagram - Active Current Limit & Thermal Protection Operation



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Timing Diagram - Basic Operation including Active Current + Internal FET SOA Protection



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SLG59H1010V Application Diagram

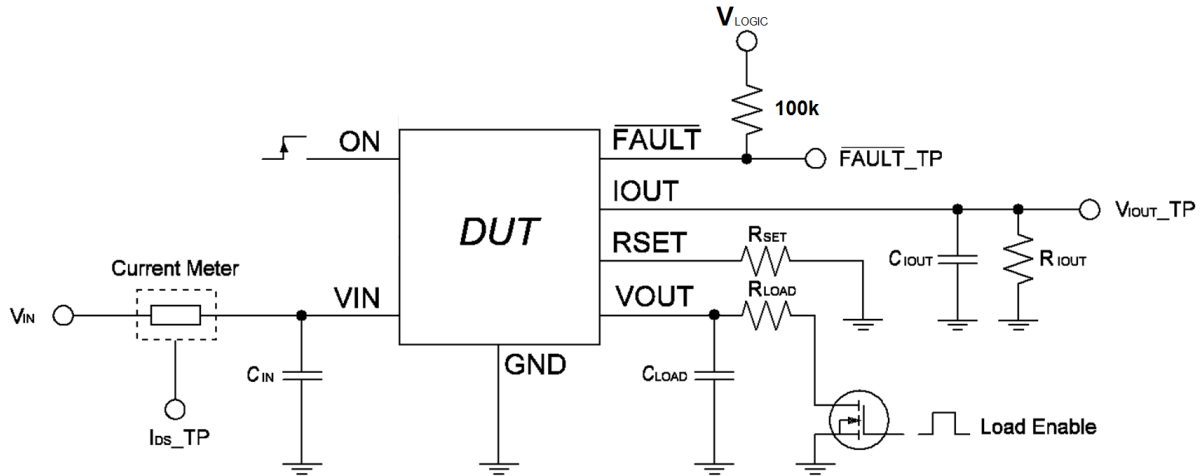


Figure 1. Test setup Application Diagram

Typical Turn-on Waveforms

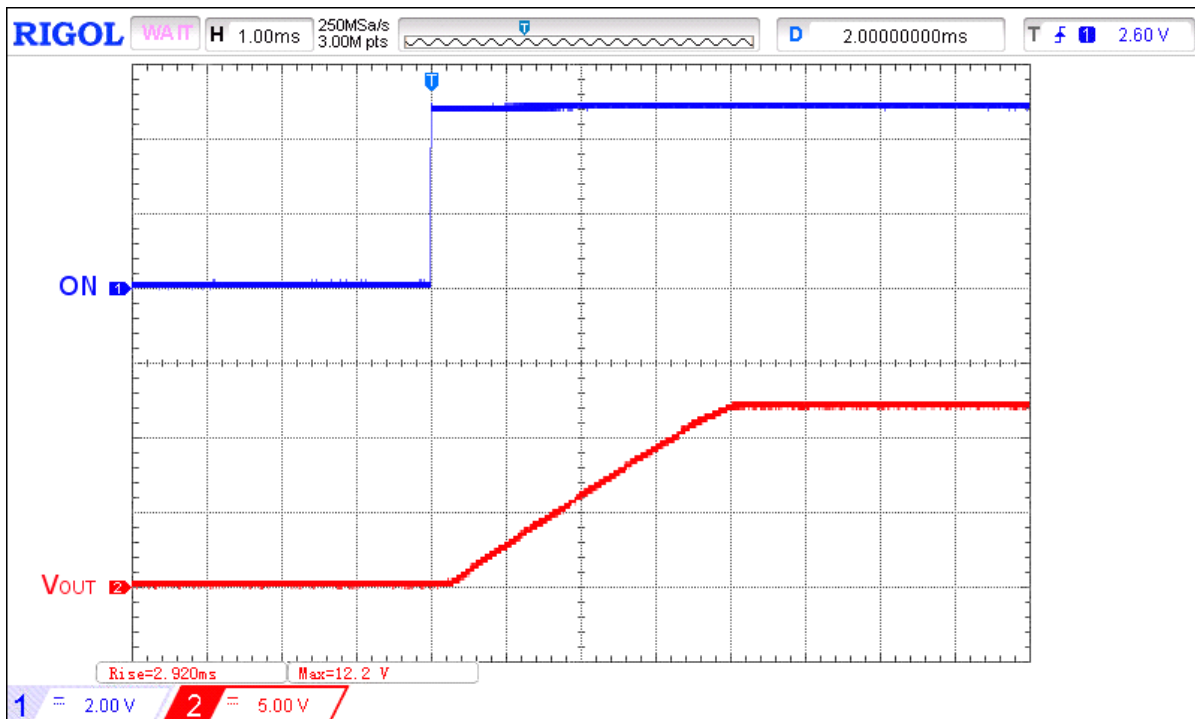


Figure 2. Typical Turn ON operation waveform for  $V_{IN} = 12\text{ V}$ ,  $C_{SLEW} = 10\text{ nF}$ ,  $C_{LOAD} = 10\text{ }\mu\text{F}$ ,  $R_{LOAD} = 100\text{ }\Omega$

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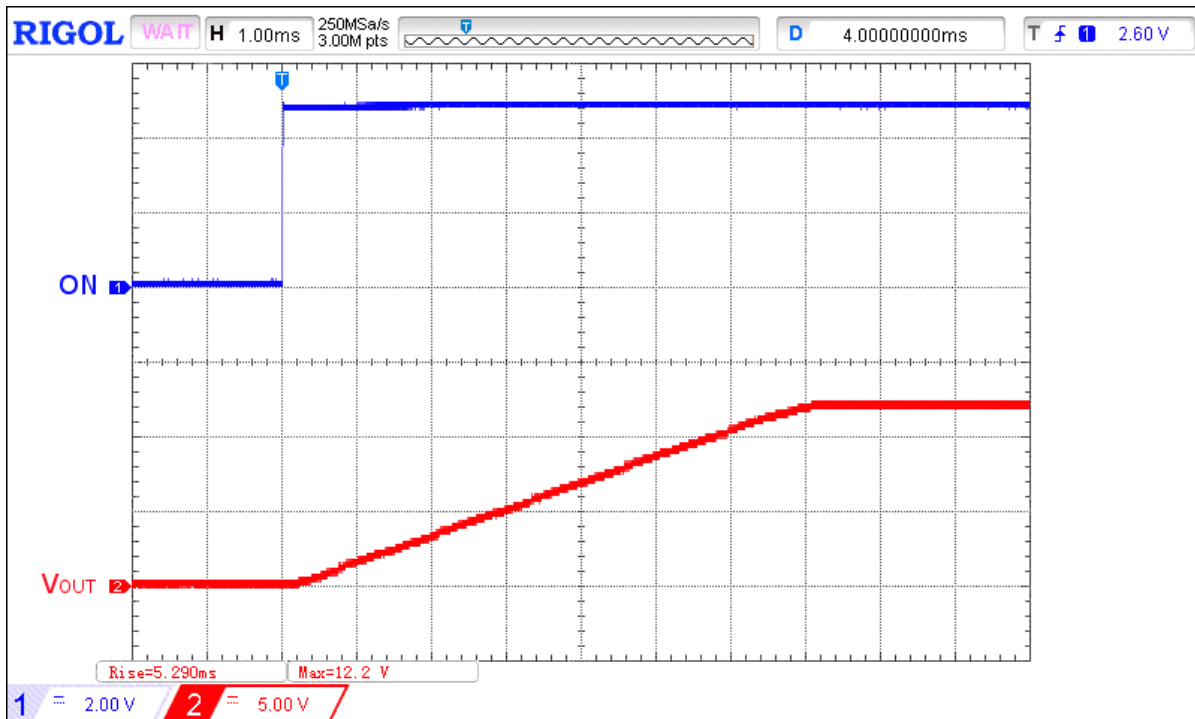


Figure 3. Typical Turn ON operation waveform for  $V_{IN} = 12\text{ V}$ ,  $C_{SLEW} = 18\text{ nF}$ ,  $C_{LOAD} = 10\text{ }\mu\text{F}$ ,  $R_{LOAD} = 100\text{ }\Omega$

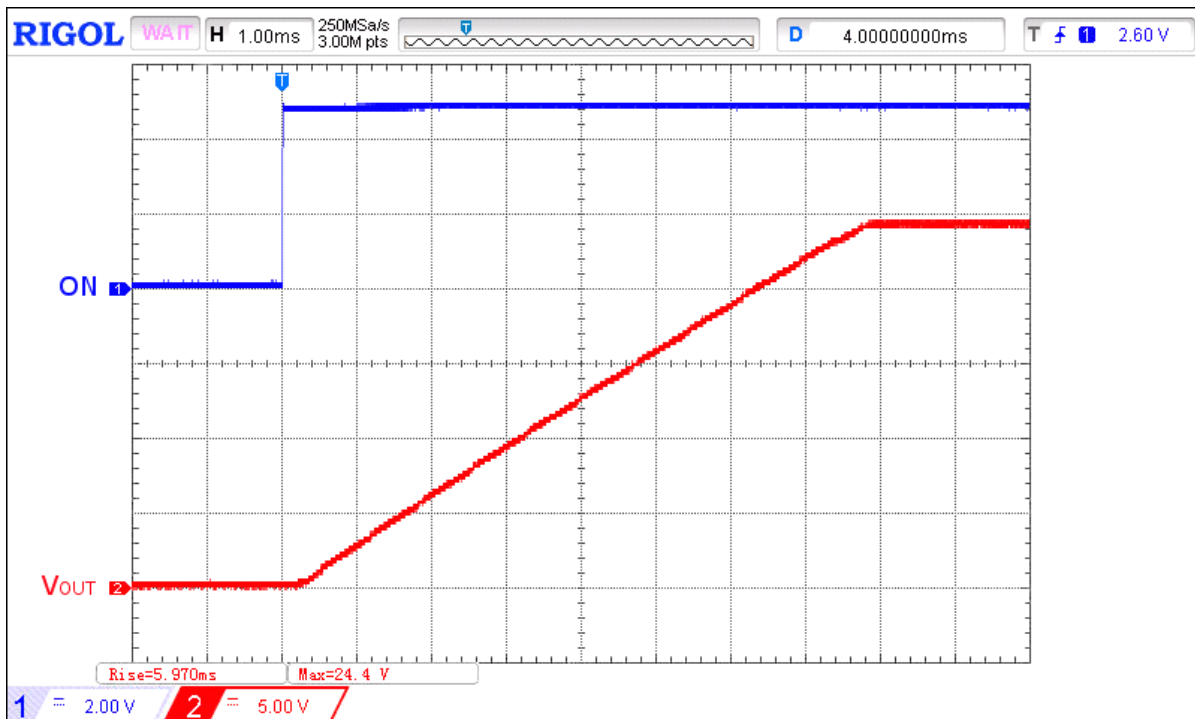


Figure 4. Typical Turn ON operation waveform for  $V_{IN} = 24\text{ V}$ ,  $C_{SLEW} = 10\text{ nF}$ ,  $C_{LOAD} = 10\text{ }\mu\text{F}$ ,  $R_{LOAD} = 100\text{ }\Omega$

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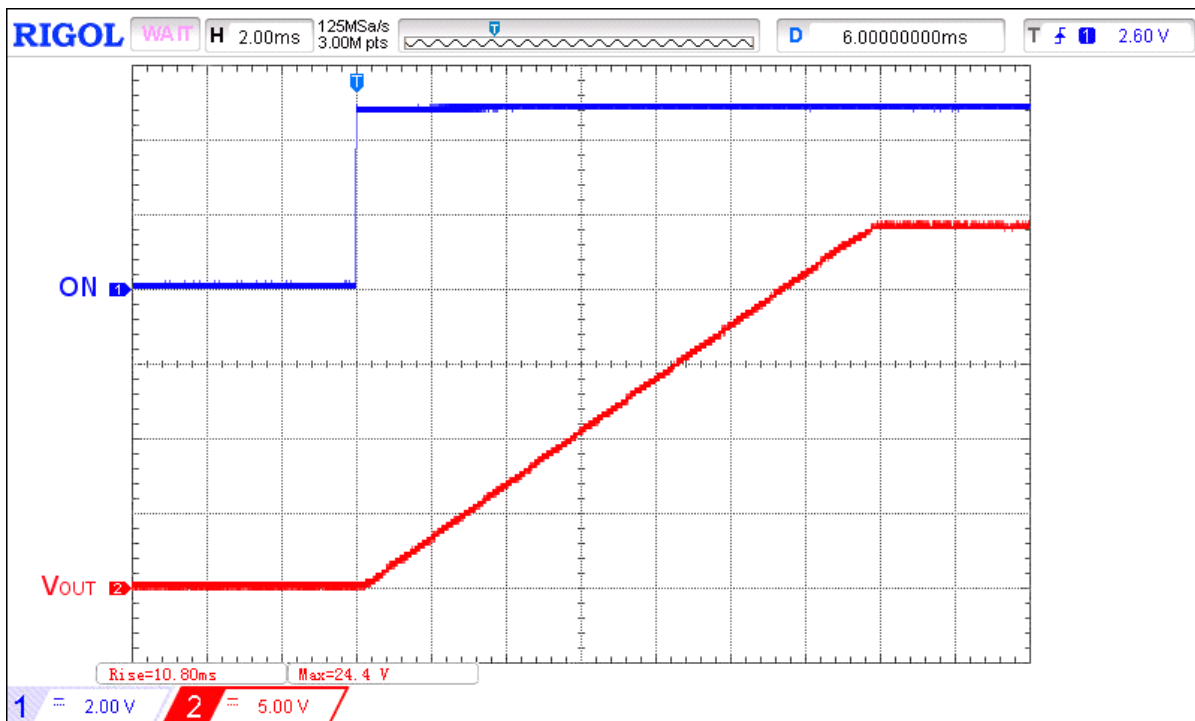


Figure 5. Typical Turn ON operation waveform for  $V_{IN} = 24\text{ V}$ ,  $C_{SLEW} = 18\text{ nF}$ ,  $C_{LOAD} = 10\text{ }\mu\text{F}$ ,  $R_{LOAD} = 100\text{ }\Omega$

Typical Turn-off Waveforms

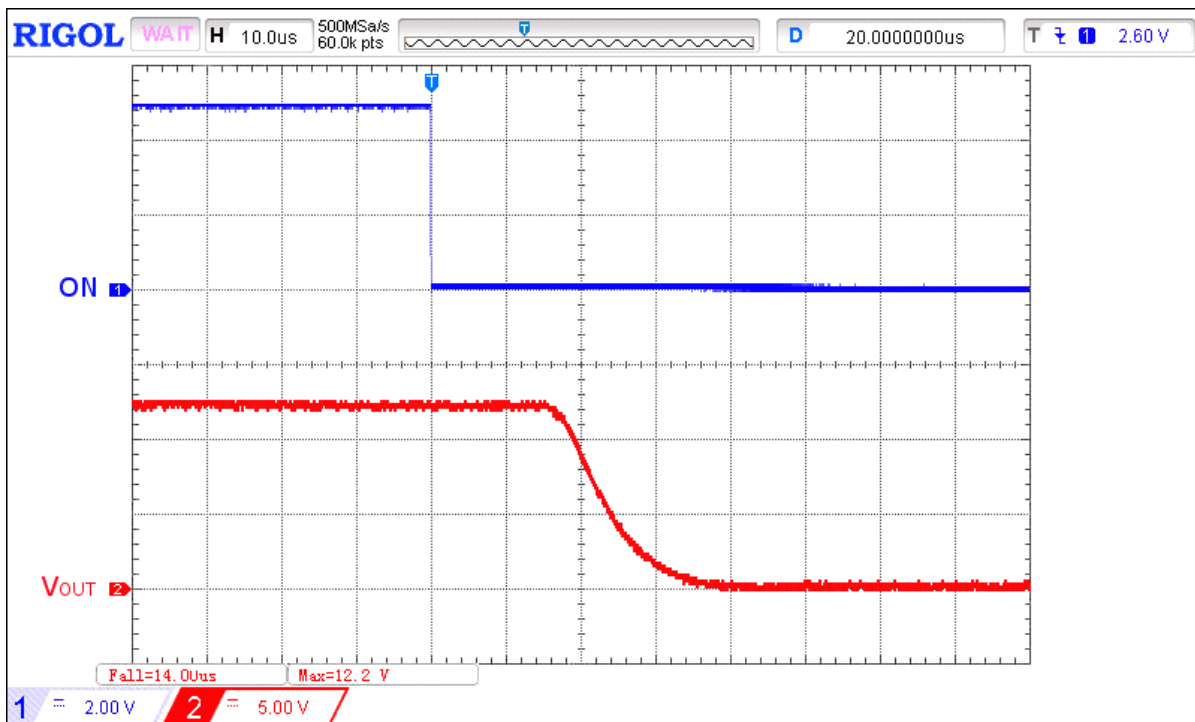


Figure 6. Typical Turn OFF operation waveform for  $V_{IN} = 12\text{ V}$ ,  $C_{SLEW} = 10\text{ nF}$ , no  $C_{LOAD}$ ,  $R_{LOAD} = 100\text{ }\Omega$

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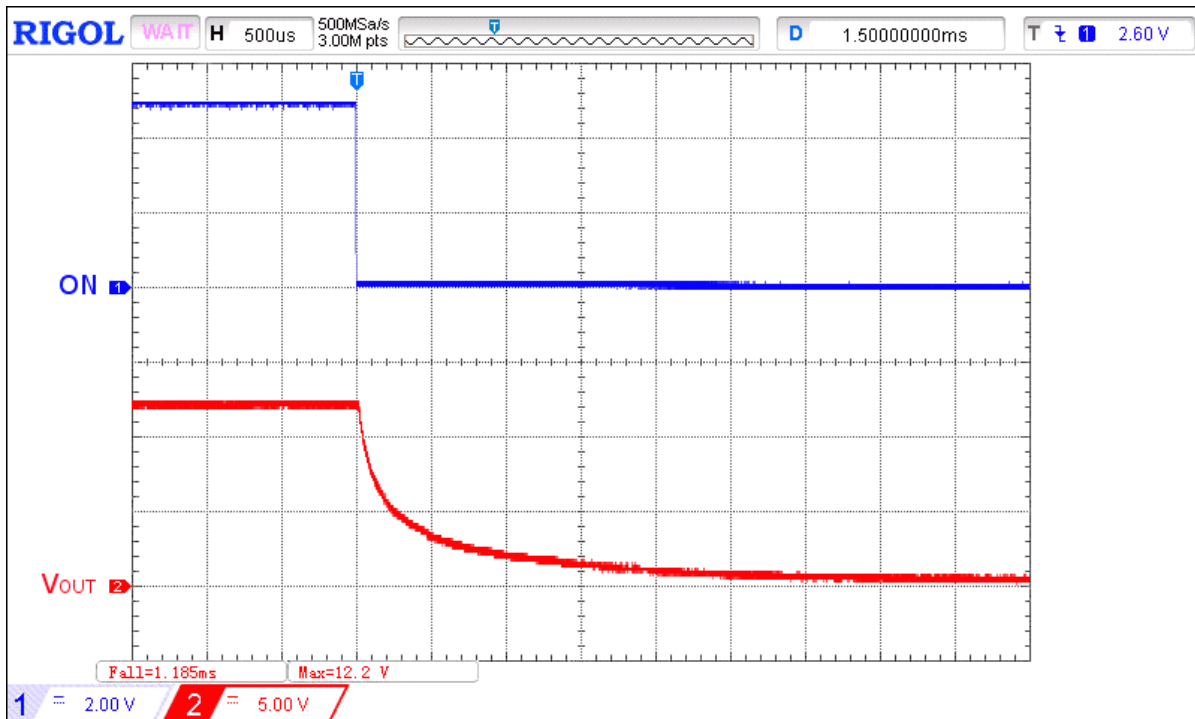


Figure 7. Typical Turn OFF operation waveform for  $V_{IN} = 12V$ ,  $C_{SLEW} = 10\text{ nF}$ ,  $C_{LOAD} = 10\text{ }\mu\text{F}$ ,  $R_{LOAD} = 100\text{ }\Omega$

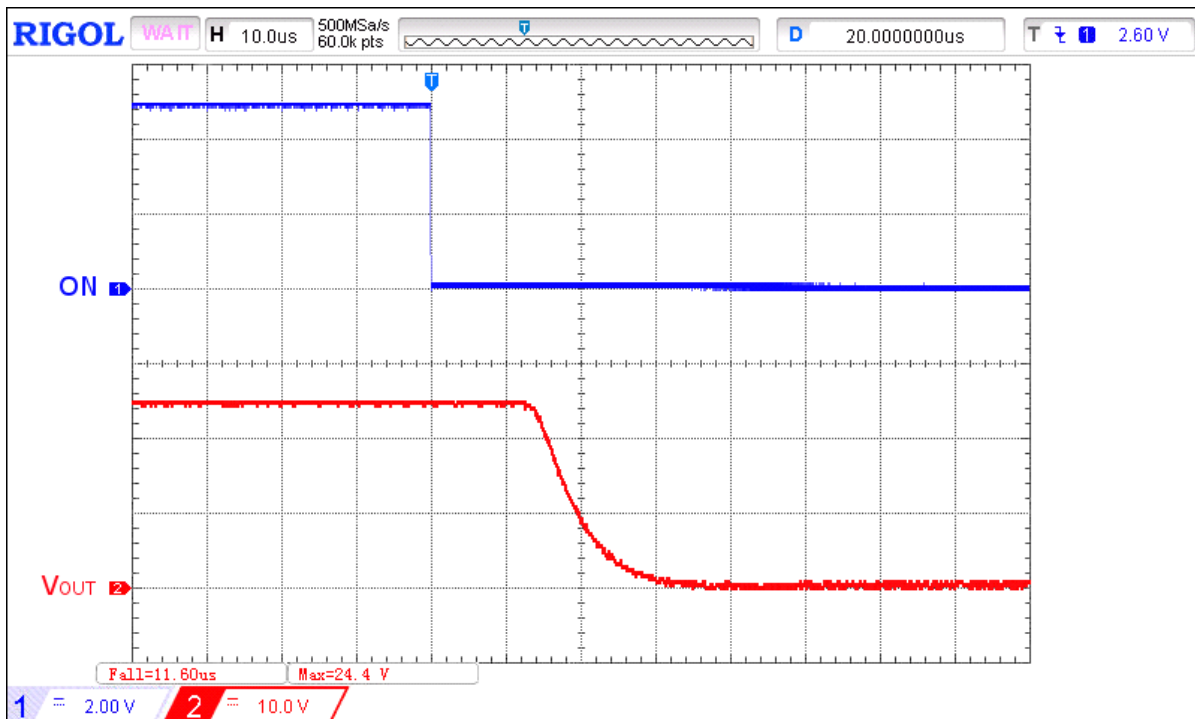


Figure 8. Typical Turn OFF operation waveform for  $V_{IN} = 24\text{ V}$ ,  $C_{SLEW} = 10\text{ nF}$ , no  $C_{LOAD}$ ,  $R_{LOAD} = 100\text{ }\Omega$



SLG59H1010V

A 13.3 mΩ, 5 A Load Switch with 12 V / 24 V  
 $V_{IN}$  Lockout Select and MOSFET Current Monitor Output

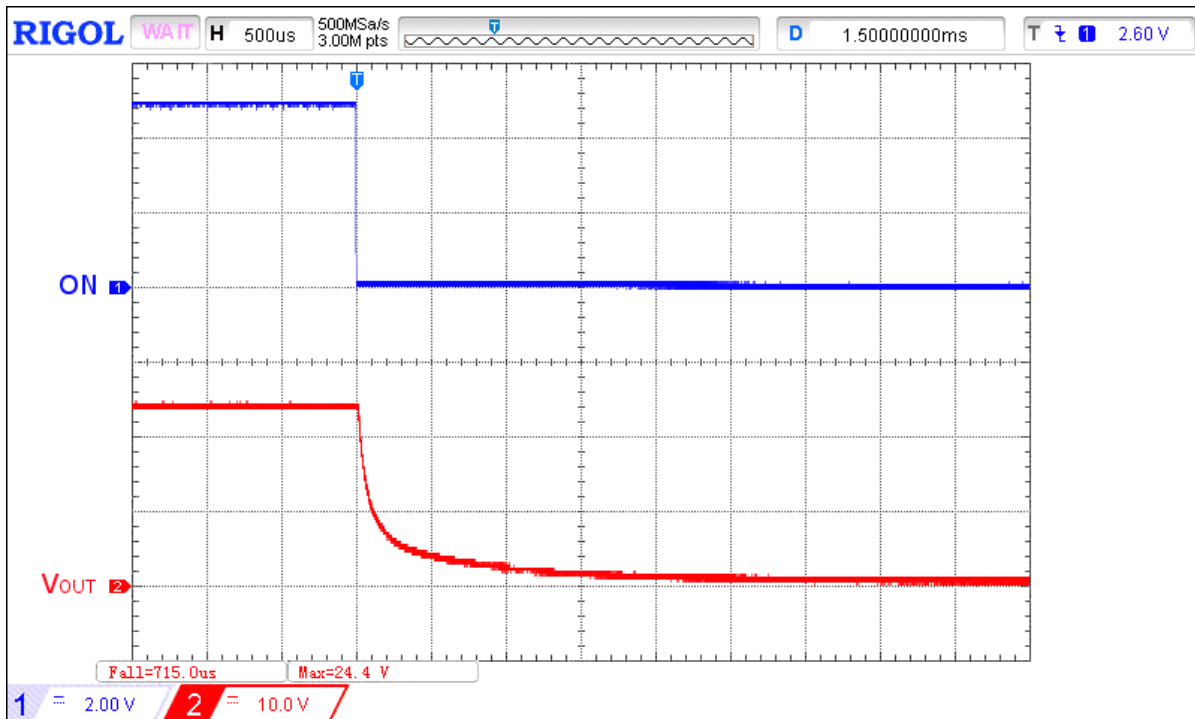


Figure 9. Typical Turn OFF operation waveform for  $V_{IN} = 24\text{ V}$ ,  $C_{SLEW} = 10\text{ nF}$ ,  $C_{LOAD} = 10\text{ }\mu\text{F}$ ,  $R_{LOAD} = 100\text{ }\Omega$

Typical ACL Operation Waveforms

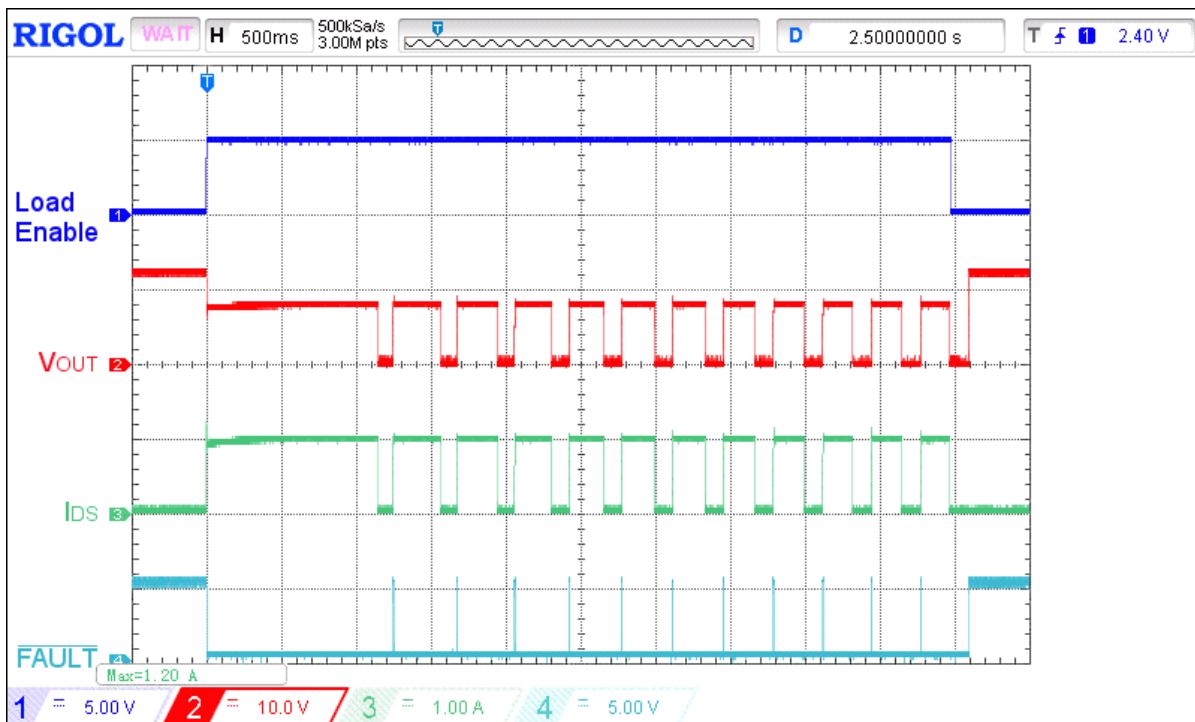


Figure 10. Typical ACL operation waveform for  $V_{IN} = 12\text{ V}$ ,  $C_{LOAD} = 10\text{ }\mu\text{F}$ ,  $I_{ACL} = 1\text{ A}$ ,  $R_{SET} = 91\text{ k}\Omega$

SLG59H1010V

A 13.3 mΩ, 5 A Load Switch with 12 V / 24 V  
 $V_{IN}$  Lockout Select and MOSFET Current Monitor Output

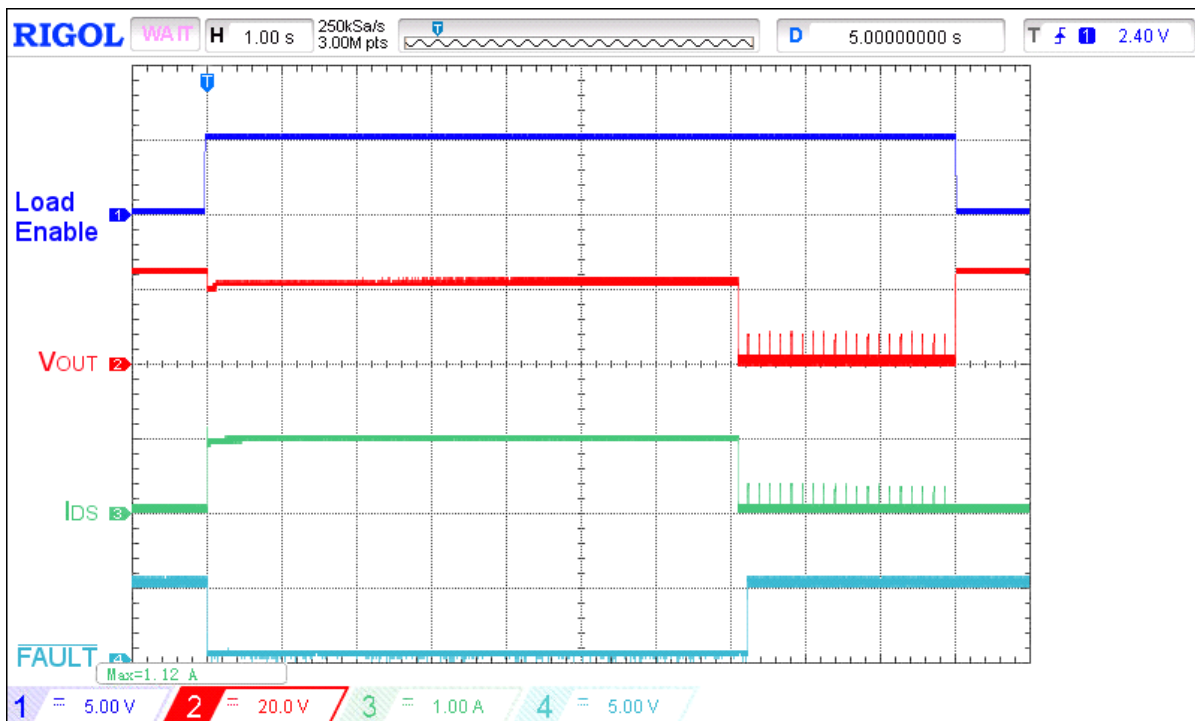


Figure 11. Thermally induced SOA shutdown for  $V_{IN} = 24\text{ V}$ ,  $C_{LOAD} = 10\ \mu\text{F}$ ,  $I_{ACL} = 1\text{ A}$ ,  $R_{SET} = 91\text{ k}\Omega$

Typical FAULT Operation Waveforms

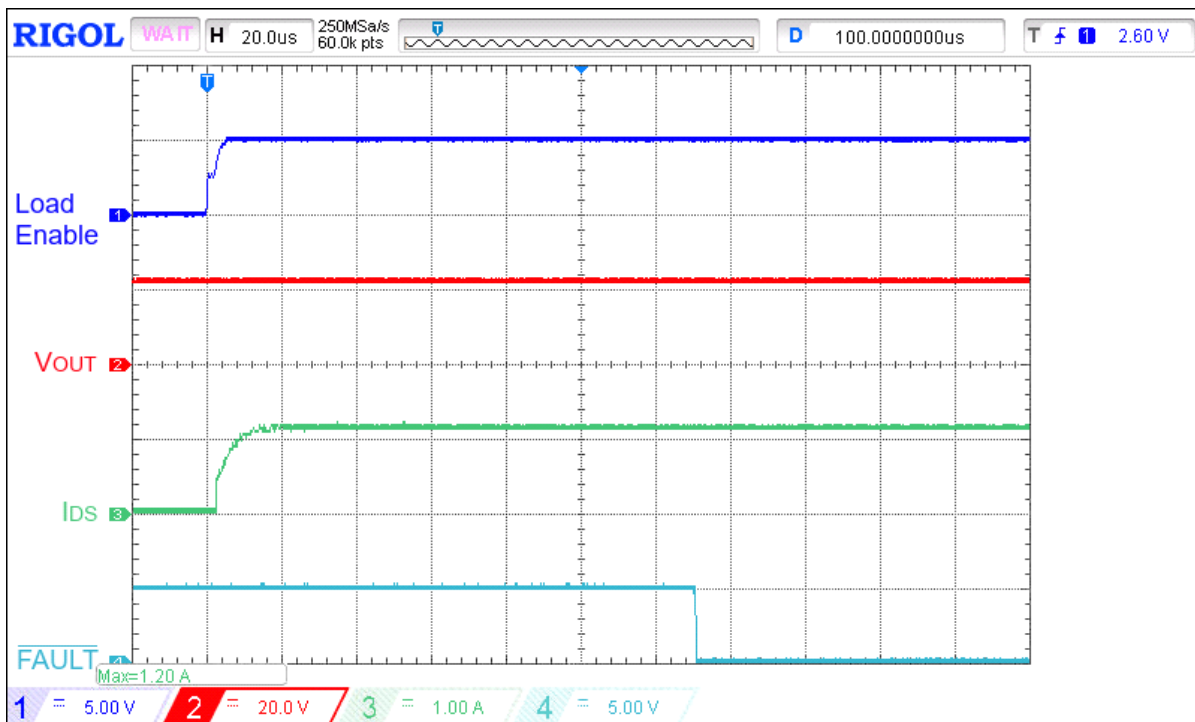


Figure 12. Typical FAULT assertion waveform for  $V_{IN} = 24\text{ V}$ ,  $C_{LOAD} = 10\ \mu\text{F}$ ,  $I_{ACL} = 1\text{ A}$ ,  $R_{SET} = 91\text{ k}\Omega$ , switch on  $18.5\ \Omega$  load

SLG59H1010V

A 13.3 mΩ, 5 A Load Switch with 12 V / 24 V  
 $V_{IN}$  Lockout Select and MOSFET Current Monitor Output

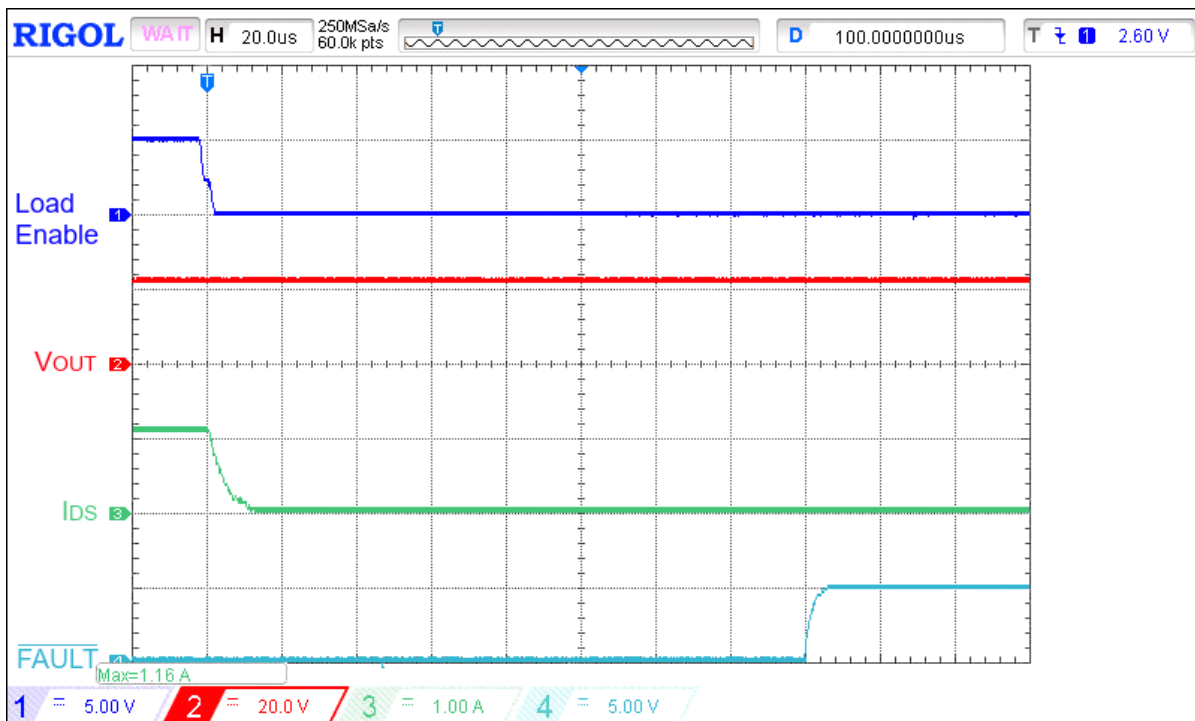


Figure 13. Typical  $\overline{\text{FAULT}}$  de-assertion waveform for  $V_{IN} = 24 \text{ V}$ ,  $C_{LOAD} = 10 \mu\text{F}$ ,  $I_{ACL} = 1 \text{ A}$ ,  $R_{SET} = 91 \text{ k}\Omega$ , switch out  $18.5 \Omega$  load

## SLG59H1010V

A 13.3 mΩ, 5 A Load Switch with 12 V / 24 V  
V<sub>IN</sub> Lockout Select and MOSFET Current Monitor Output

### Applications Information

#### High Voltage GreenFET Safe Operating Area Explained

Renesas's High Voltage GreenFET load switches incorporate a number of internal protection features that prevents them from damaging themselves or any other circuit or subcircuit downstream of them. One particular protection feature is their Safe Operation Area (SOA) protection. SOA protection is automatically activated under overpower and, in some cases, under overcurrent conditions. Overpower SOA is activated if package power dissipation exceeds an internal 5 W threshold longer than 2.5 ms. High Voltage GreenFET devices will quickly switch off (open circuit) upon overpower detection and automatically resume (close) nominal operation once overpower condition no longer exists.

One possible way to have an overpower condition trigger SOA protection is when High Voltage GreenFET products are enabled into heavy output resistive loads and/or into large load capacitors. It is under these conditions to follow carefully the "Safe Start-up Loading" guidance in the Applications section of the datasheet. During an overcurrent condition, High Voltage GreenFET devices will try to limit the output current to the level set by the external R<sub>SET</sub> resistor. Limiting the output current, however, causes an increased voltage drop across the FET's channel because the FET's R<sub>DS(ON)</sub> increased as well. Since the FET's R<sub>DS(ON)</sub> is larger, package power dissipation also increases. If the resultant increase in package power dissipation is higher/equal than 5 W for longer than 2.5 ms, internal SOA protection will be triggered and the FET will open circuit (switch off). Every time SOA protection is triggered, all High Voltage GreenFET devices will automatically attempt to resume nominal operation after 160 ms.

#### Safe Start-up Condition

SLG59H1010V has built-in protection to prevent over-heating during start-up into a heavy load. Overloading the V<sub>OUT</sub> pin with a capacitor and a resistor may result in non-monotonic V<sub>OUT</sub> ramping. In general, under light loading on V<sub>OUT</sub>, V<sub>OUT</sub> ramping can be controlled with C<sub>SLEW</sub> value. The following equation serves as a guide:

$$C_{SLEW} = \frac{T_{RISE}}{V_{IN}} \times 4.9 \mu A \times \frac{20}{3}$$

where

T<sub>RISE</sub> = Total rise time from 10% V<sub>OUT</sub> to 90% V<sub>OUT</sub>

V<sub>IN</sub> = Input Voltage

C<sub>SLEW</sub> = Capacitor value for CAP pin

When capacitor and resistor loading on V<sub>OUT</sub> during start up, the following tables will ensure V<sub>OUT</sub> ramping is monotonic without triggering internal protection:

| Safe Start-up Loading for V <sub>IN</sub> = 12 V (Monotonic Ramp) |                                     |                        |                       |
|---|-------------------------------------|------------------------|-----------------------|
| Slew Rate (V/ms)  | C <sub>SLEW</sub> (nF) <sup>2</sup> | C <sub>LOAD</sub> (μF) | R <sub>LOAD</sub> (Ω) |
| 1   | 33.3                                | 500                    | 20                    |
| 2   | 16.7                                | 250                    | 20                    |
| 3   | 11.1                                | 160                    | 20                    |
| 4   | 8.3                                 | 120                    | 20                    |
| 5   | 6.7                                 | 100                    | 20                    |

# SLG59H1010V

A 13.3 mΩ, 5 A Load Switch with 12 V / 24 V  
 $V_{IN}$  Lockout Select and MOSFET Current Monitor Output

| Safe Start-up Loading for $V_{IN} = 24\text{ V}$ (Monotonic Ramp) |                              |                 |                |
|---|------------------------------|-----------------|----------------|
| Slew Rate (V/ms)  | $C_{SLEW}$ (nF) <sup>2</sup> | $C_{LOAD}$ (μF) | $R_{LOAD}$ (Ω) |
| 0.5   | 66.7                         | 500             | 80             |
| 1.0   | 33.3                         | 250             | 80             |
| 1.5   | 22.2                         | 160             | 80             |
| 2.0   | 16.7                         | 120             | 80             |
| 2.5   | 13.3                         | 100             | 80             |

Note 2: Select the closest-value tolerance capacitor.

## Setting the SLG59H1010V's Active Current Limit

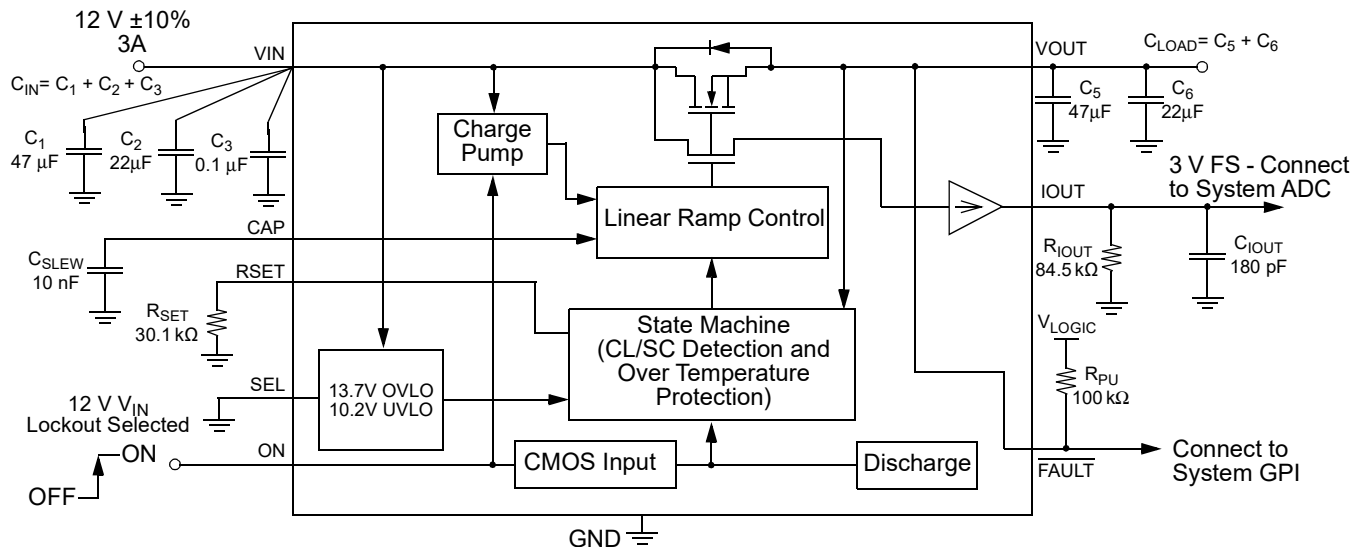
| $R_{SET}$ (kΩ) | Active Current Limit (A) <sup>3</sup> |
|----------------|---------------------------------------|
| 91             | 1                                     |
| 45             | 2                                     |
| 30             | 3                                     |
| 18             | 5                                     |

Note 3: Active Current Limit accuracy is  $\pm 15\%$  over voltage range and over temperature range.

## Configuring the SLG59H1010V for 12 V $V_{IN}$ Lockout Applications

To configure the SLG59H1010V for conditioned 12 V  $\pm 10\%$   $V_{IN}$  applications is simply a matter of connecting the SEL pin to GND as shown in Figure A. For other  $V_{IN}$  lockout window applications, please consult Renesas for additional information.

Figure A.



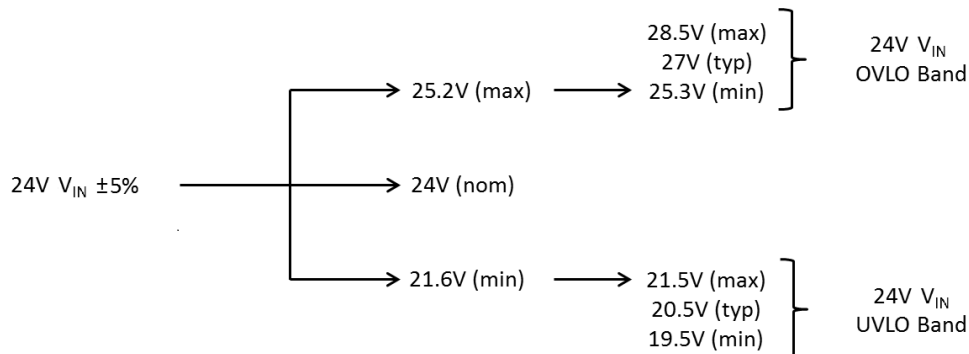
## SLG59H1010V

### A 13.3 mΩ, 5 A Load Switch with 12 V / 24 V V<sub>IN</sub> Lockout Select and MOSFET Current Monitor Output

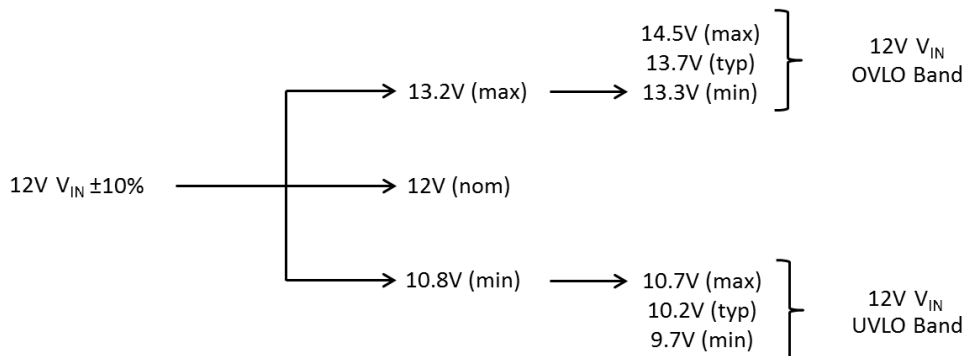
#### 24 V V<sub>IN</sub> and 12 V V<sub>IN</sub> Lockout Window Thresholds

Shown in Figure B and Figure C are the two sets of V<sub>IN</sub> overvoltage/undervoltage lockout windows – one for conditioned 24 V ±5% V<sub>IN</sub> systems and the second for conditioned 12 V ±10% V<sub>IN</sub> systems. To avoid lockout threshold collision with nominal operation, the SLG59H1010V's V<sub>IN(OVLO)</sub> min and V<sub>IN(UVLO)</sub> max thresholds were set 0.1 V correspondingly higher than the system's nominal V<sub>IN</sub> max or lower than the system's V<sub>IN</sub> min range.

**Figure B.**



**Figure C.**



#### Power Dissipation

The junction temperature of the SLG59H1010V depends on different factors such as board layout, ambient temperature, and other environmental factors. The primary contributor to the increase in the junction temperature of the SLG59H1010V is the power dissipation of its power MOSFET. Its power dissipation and the junction temperature in nominal operating mode can be calculated using the following equations:

$$PD = RDS_{ON} \times I_{DS}^2$$

where:

PD = Power dissipation, in Watts (W)

RDS<sub>ON</sub> = Power MOSFET ON resistance, in Ohms (Ω)

I<sub>DS</sub> = Output current, in Amps (A)

and

$$T_J = PD \times \theta_{JA} + T_A$$

where:

T<sub>J</sub> = Junction temperature, in Celsius degrees (°C)

θ<sub>JA</sub> = Package thermal resistance, in Celsius degrees per Watt (°C/W)

T<sub>A</sub> = Ambient temperature, in Celsius degrees (°C)

## SLG59H1010V

A 13.3 mΩ, 5 A Load Switch with 12 V / 24 V  
 $V_{IN}$  Lockout Select and MOSFET Current Monitor Output

### Power Dissipation (continued)

In current-limit mode, the SLG59H1010V's power dissipation can be calculated by taking into account the voltage drop across the load switch ( $V_{IN}-V_{OUT}$ ) and the magnitude of the output current in current-limit mode ( $I_{ACL}$ ):

$$PD = (V_{IN}-V_{OUT}) \times I_{ACL} \text{ or}$$

$$PD = (V_{IN} - (R_{LOAD} \times I_{ACL})) \times I_{ACL}$$

where:

PD = Power dissipation, in Watts (W)  
 $V_{IN}$  = Input Voltage, in Volts (V)  
 $R_{LOAD}$  = Load Resistance, in Ohms ( $\Omega$ )  
 $I_{ACL}$  = Output limited current, in Amps (A)  
 $V_{OUT} = R_{LOAD} \times I_{ACL}$



## SLG59H1010V

A 13.3 mΩ, 5 A Load Switch with 12 V / 24 V  
 $V_{IN}$  Lockout Select and MOSFET Current Monitor Output

### Layout Guidelines:

1. Since the  $V_{IN}$  and  $V_{OUT}$  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 absolute minimum widths of 15 mils (0.381 mm) per Ampere. A representative layout, shown in [Figure 14](#), 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 SLG59H1010V's  $V_{IN}$  and  $V_{OUT}$  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.

### SLG59H1010V Evaluation Board:

A High Voltage GreenFET Evaluation Board for SLG59H1010V is designed according to the statements above and is illustrated on [Figure 14](#). Please note that evaluation board has D\_Sense and S\_Sense pads. They cannot carry high currents and dedicated only for  $R_{DS(ON)}$  evaluation.

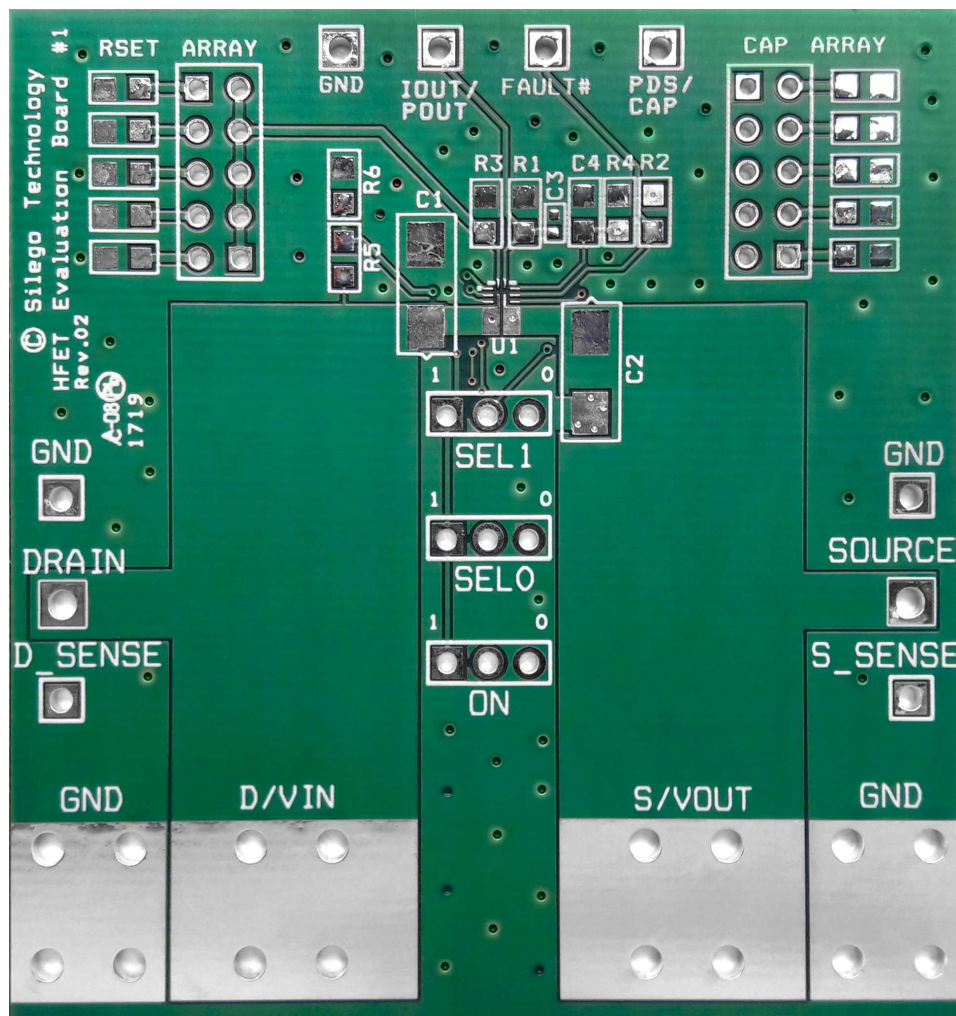


Figure 14. SLG59H1010V Evaluation Board



# SLG59H1010V

A 13.3 mΩ, 5 A Load Switch with 12 V / 24 V  
 $V_{IN}$  Lockout Select and MOSFET Current Monitor Output

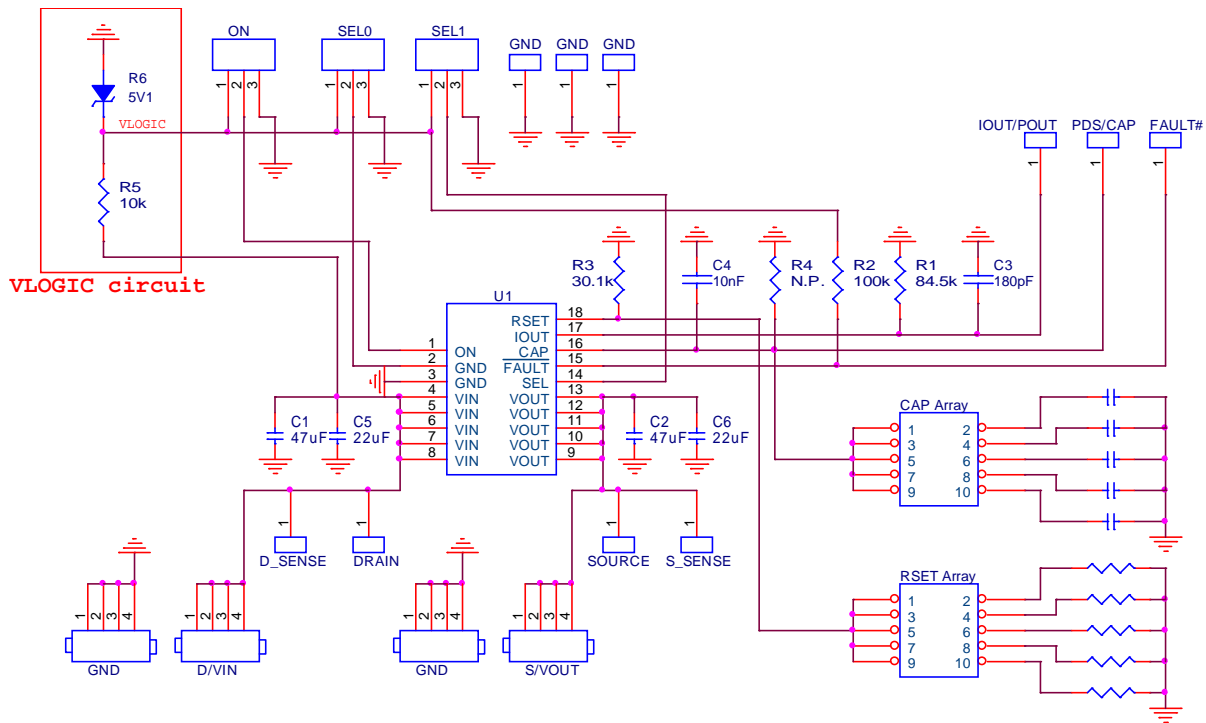


Figure 15. SLG59H1010V Evaluation Board Connection Circuit

## Basic Test Setup and Connections

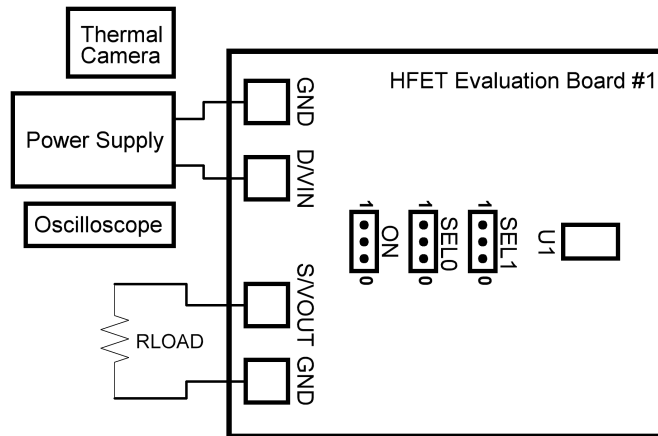


Figure 16. SLG59H1010V Evaluation Board Connection Circuit

### EVB Configuration

1. Set SEL0 to GND;
2. Based on  $V_{IN}$  voltage, set SEL1 to GND or 5 V to configure OVLO;
3. Connect oscilloscope probes to D/VIN, S/VOUT, ON, etc.;
4. Turn on Power Supply and set  $V_{IN}$  to 12 V or 24 V;
5. Toggle the ON signal High or Low to observe SLG59H1010V operation.

SLG59H1010V

A 13.3 mΩ, 5 A Load Switch with 12 V / 24 V  
 $V_{IN}$  Lockout Select and MOSFET Current Monitor Output

Test Result

Using thermal camera, we tested thermal distribution on the PCB after 2 min power up at  $V_{IN} = 24\text{ V}$  and  $I_{DS} = 4.5\text{ A}$ . Please note how evenly temperature is distributed on the PCB that prove a proper design of PCB and thus other components around High Voltage GreenFET will be not overheated. High Voltage GreenFET temperature is only  $17\text{ }^{\circ}\text{C}$  above the lab ambient temperature. Top left corner displays temperature in the “x” position of thermal camera. Right corner from top to bottom displays full scale of temperatures.

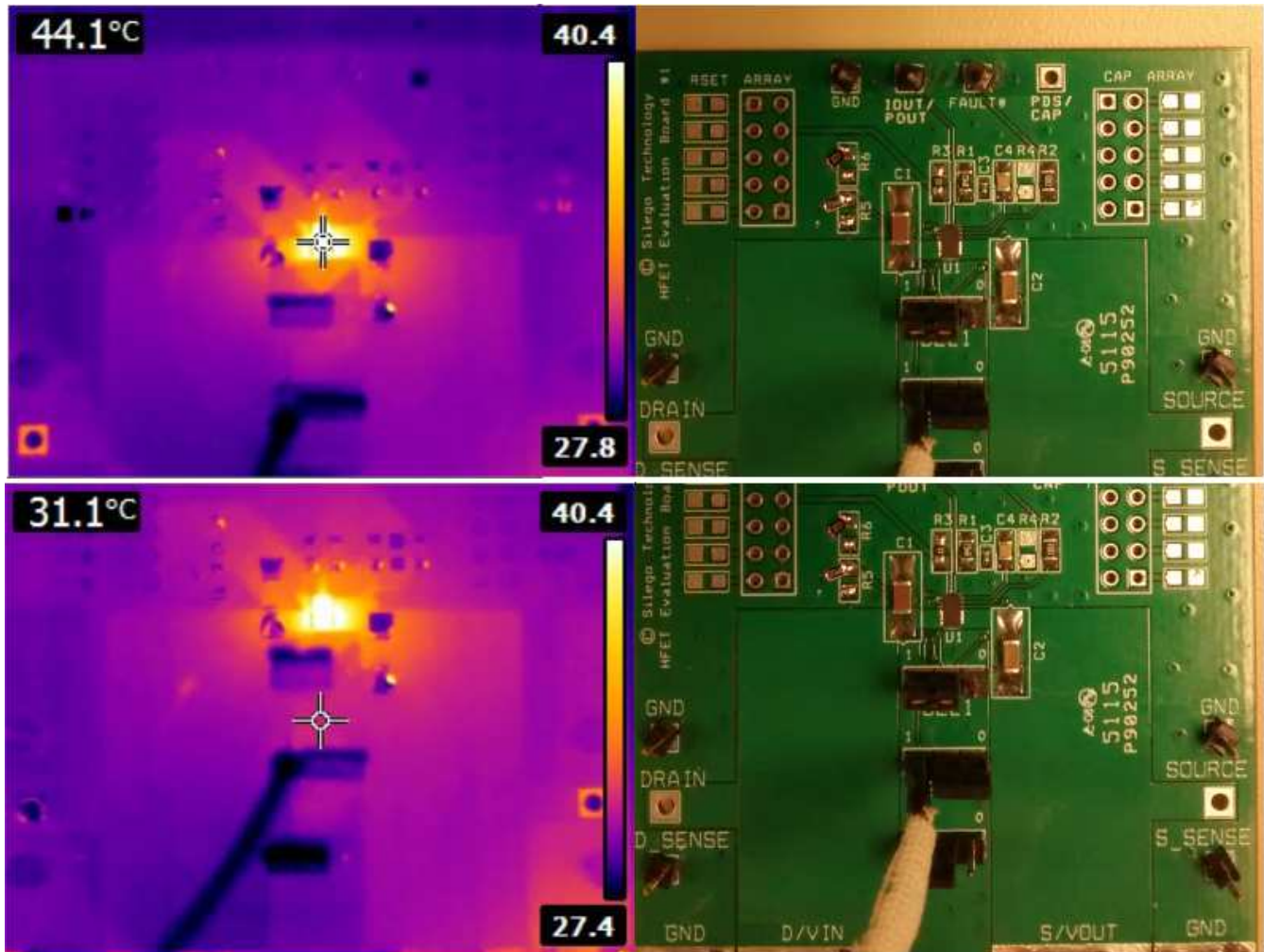
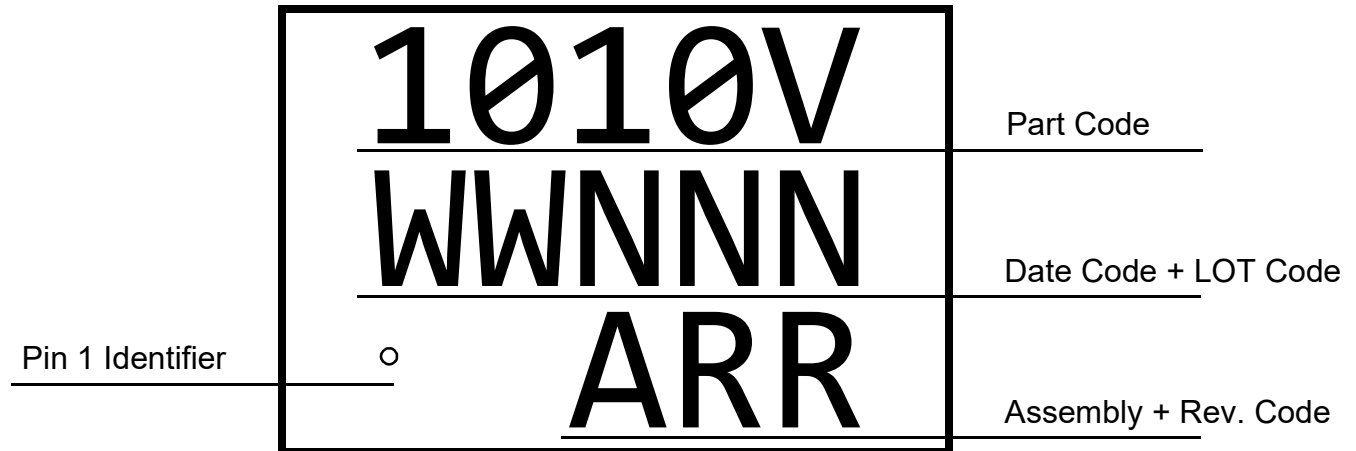


Figure 17. Thermal distribution for  $V_{IN} = 24\text{ V}$ ,  $I_{DS} = 4.5\text{ A}$  after 2 min power up

**SLG59H1010V**

A 13.3 mΩ, 5 A Load Switch with 12 V / 24 V  
 V<sub>IN</sub> Lockout Select and MOSFET Current Monitor Output

**Package Top Marking System Definition**



- 1010V - Part ID Field
- WW - Date Code Field<sup>1</sup>
- NNN - Lot Traceability Code Field<sup>1</sup>
- A - Assembly Site Code Field<sup>2</sup>
- RR - Part Revision Code Field<sup>2</sup>

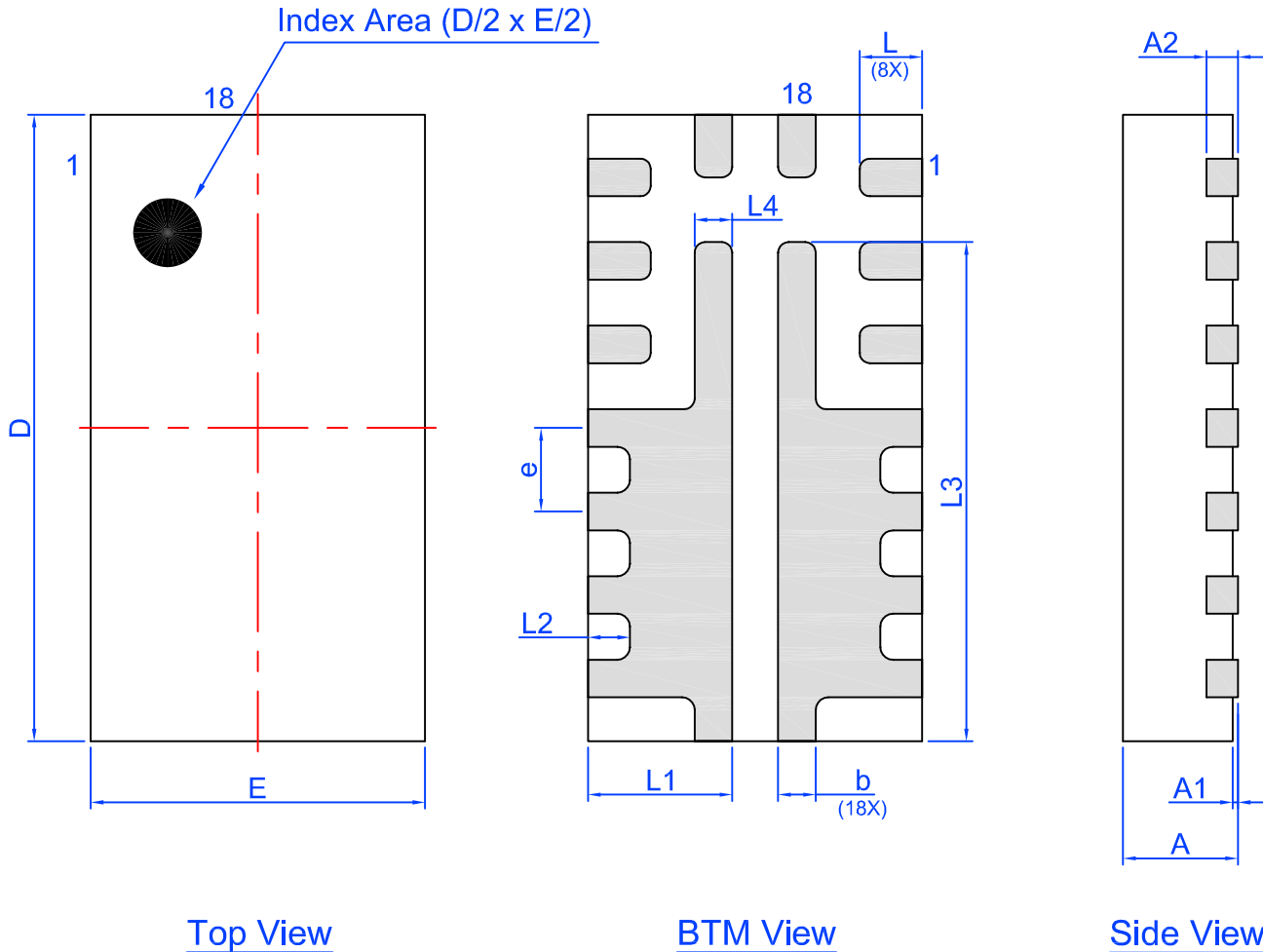
Note 1: Each character in code field can be alphanumeric A-Z and 0-9  
 Note 2: Character in code field can be alphabetic A-Z

# SLG59H1010V

A 13.3 mΩ, 5 A Load Switch with 12 V / 24 V  
 $V_{IN}$  Lockout Select and MOSFET Current Monitor Output

## Package Drawing and Dimensions

18 Lead TQFN Package 1.6 x 3 mm (Fused Lead)  
 JEDEC MO-220, Variation WCEE



Top View

BTM View

Side View

Unit: mm

| Symbol | Min      | Nom. | Max  | Symbol | Min  | Nom. | Max  |
|--------|----------|------|------|--------|------|------|------|
| A      | 0.50     | 0.55 | 0.60 | D      | 2.95 | 3.00 | 3.05 |
| A1     | 0.005    | -    | 0.05 | E      | 1.55 | 1.60 | 1.65 |
| A2     | 0.10     | 0.15 | 0.20 | L      | 0.25 | 0.30 | 0.35 |
| b      | 0.13     | 0.18 | 0.23 | L1     | 0.64 | 0.69 | 0.74 |
| e      | 0.40 BSC |      |      | L2     | 0.15 | 0.20 | 0.25 |
| L3     | 2.34     | 2.39 | 2.44 | L4     | 0.13 | 0.18 | 0.23 |

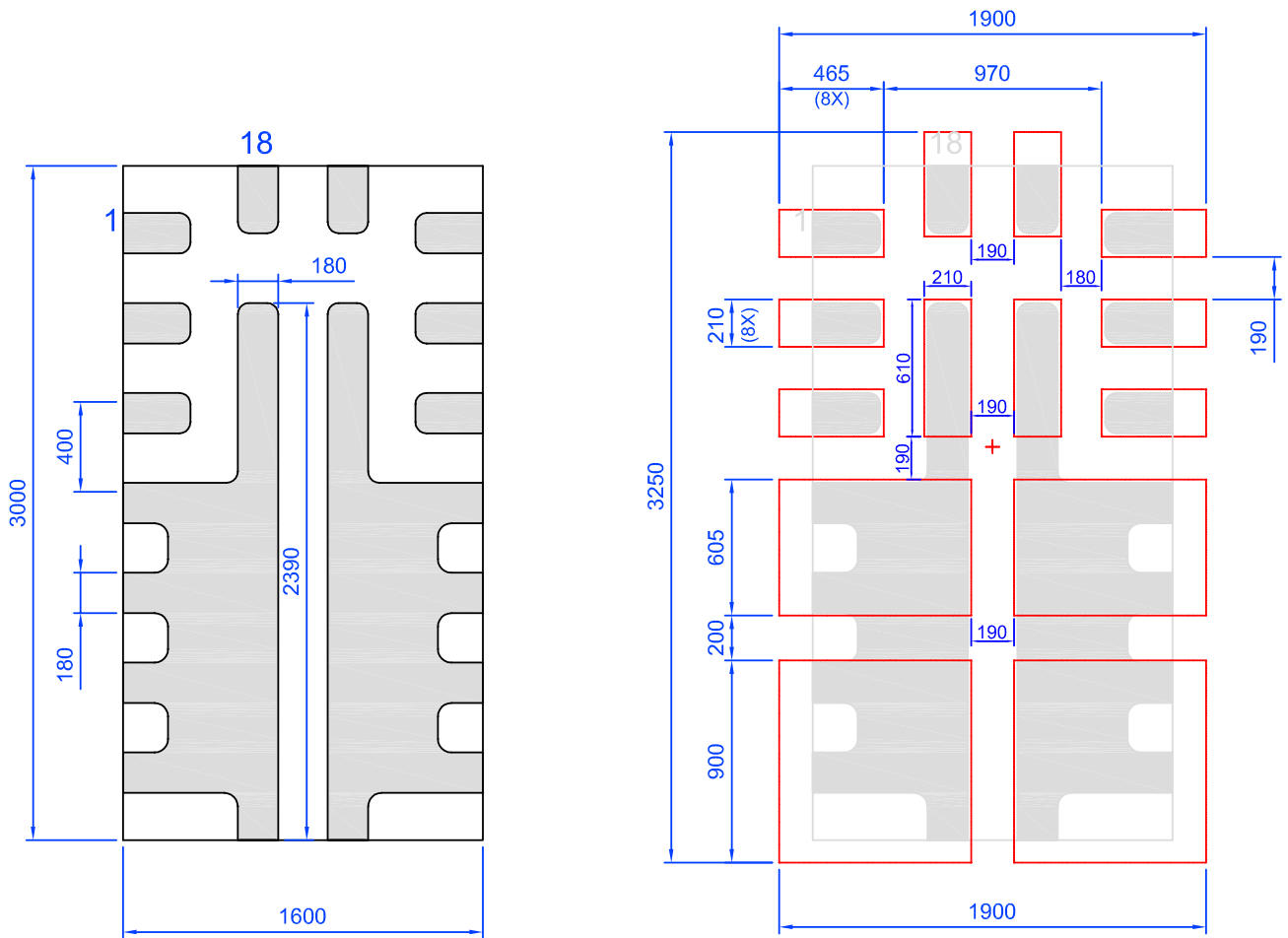
**SLG59H1010V**

A 13.3 mΩ, 5 A Load Switch with 12 V / 24 V  
 $V_{IN}$  Lockout Select and MOSFET Current Monitor Output

**SLG59H1010V 18-pin STQFN PCB Landing Pattern**

 Exposed Pad  
(PKG face down)

 Recommended Land Pattern  
(PKG face down)



Note: All dimensions shown in micrometers ( $\mu\text{m}$ )

## SLG59H1010V

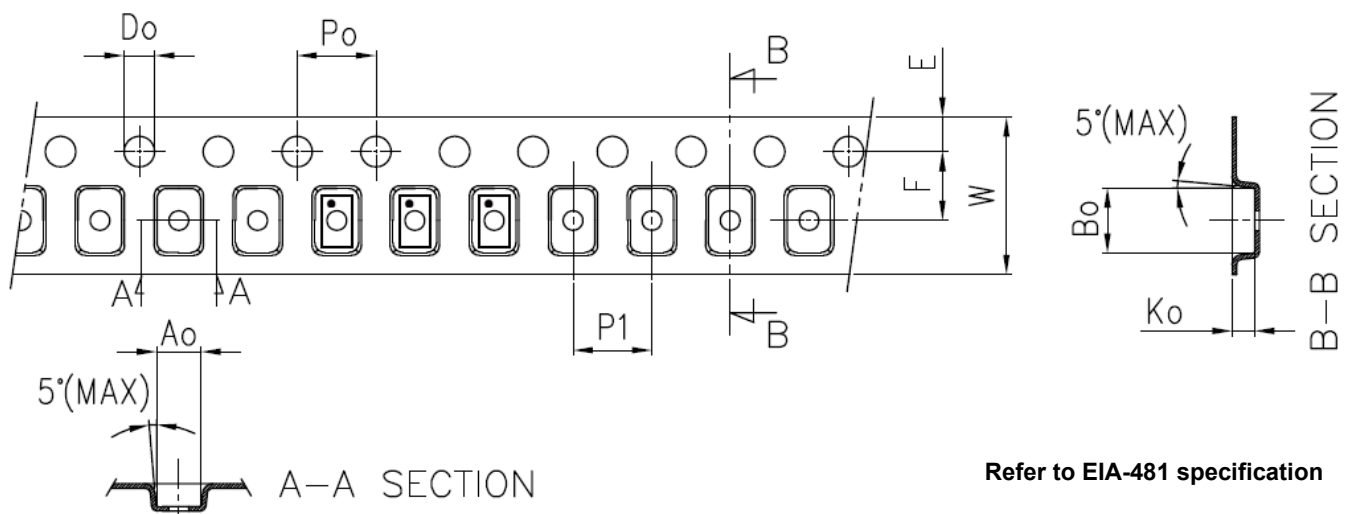
A 13.3 mΩ, 5 A Load Switch with 12 V / 24 V  
 $V_{IN}$  Lockout Select and MOSFET Current Monitor Output

### 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] |                 |                 |
| STQFN 18L<br>1.6x3mm<br>0.4P FC<br>Green | 18        | 1.6 x 3 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          |
| STQFN 18L<br>1.6x3mm<br>0.4P FC<br>Green | 1.78              | 3.18             | 0.76         | 4                | 4            | 1.5                 | 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 2.64 mm<sup>3</sup> (nominal). More information can be found at [www.jedec.org](http://www.jedec.org).

## SLG59H1010V

A 13.3 mΩ, 5 A Load Switch with 12 V / 24 V  
 $V_{IN}$  Lockout Select and MOSFET Current Monitor Output

### Revision History Renesas

| Date       | Version | Change  |
|------------|---------|---|
| 2/2/2022   | 1.03    | Updated Company name and logo<br>Added SOA Protection Threshold to Features<br>Fixed typos<br>Updated EVB image |
| 12/12/2018 | 1.02    | Updated style and formatting<br>Updated Charts<br>Added Scopeshots<br>Added Layout Guidelines<br>Fixed typos    |
| 11/2/2017  | 1.01    | Updated $V_{IN}$ Max and $V_{IN(OVLO)}$ Min<br>Updated Charts<br>Fixed typos and formatting                     |
| 2/24/2017  | 1.00    | Production Release  |

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