

# SLG59M1735C

## A 10.5 mΩ, 4 A Load Switch with Soft-start and Protection Features in WLCSP

### General Description

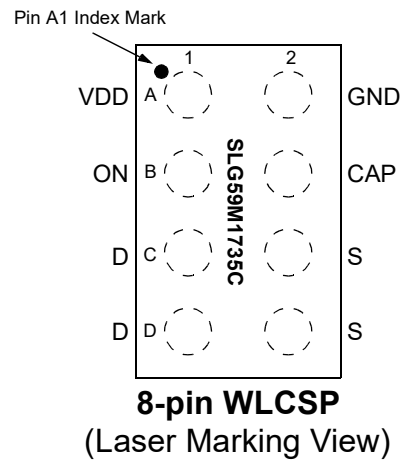
The SLG59M1735C is a high performance 10.5 mΩ, 4 A single-channel nFET load switch which can operate with a 2.5 V to 5.5 V  $V_{DD}$  supply to switch power rails from as low as 0.9 V up to the supply voltage. The SLG59M1735C incorporates two-level overload current protection, thermal shutdown protection, and soft-start control which can easily be adjusted by a small external capacitor.

Using a proprietary MOSFET design, the SLG59M1735C achieves its stable 10.5 mΩ  $R_{DS(ON)}$  across a wide input voltage range. Through the application of Renesas's proprietary CuFET technology, the SLG59M1735C's can be used in high-current applications with a very-small 1.5 mm<sup>2</sup> WLCSP form factor.

### Features

- Low  $R_{DS(ON)}$  nFET: 10.5 mΩ
- Steady-state Operating Current: Up to 4 A
- Supply Voltage:  $2.5\text{ V} \leq V_{DD} \leq 5.5\text{ V}$
- Wide Input Voltage Range:  $0.9\text{ V} \leq V_D \leq V_{DD}$
- Capacitor-adjustable Soft-start Control
- Two-stage Overcurrent Protection:
  - Fixed 6 A Active Current Limit
  - Fixed 0.5 A Short-circuit Current Limit
- Thermal Shutdown Protection
- Operating Temperature: -40 °C to 85 °C
- 0.96 mm x 1.56 mm, 0.4mm pitch 8L WLCSP
  - Pb-Free / Halogen-Free / RoHS-Compliant

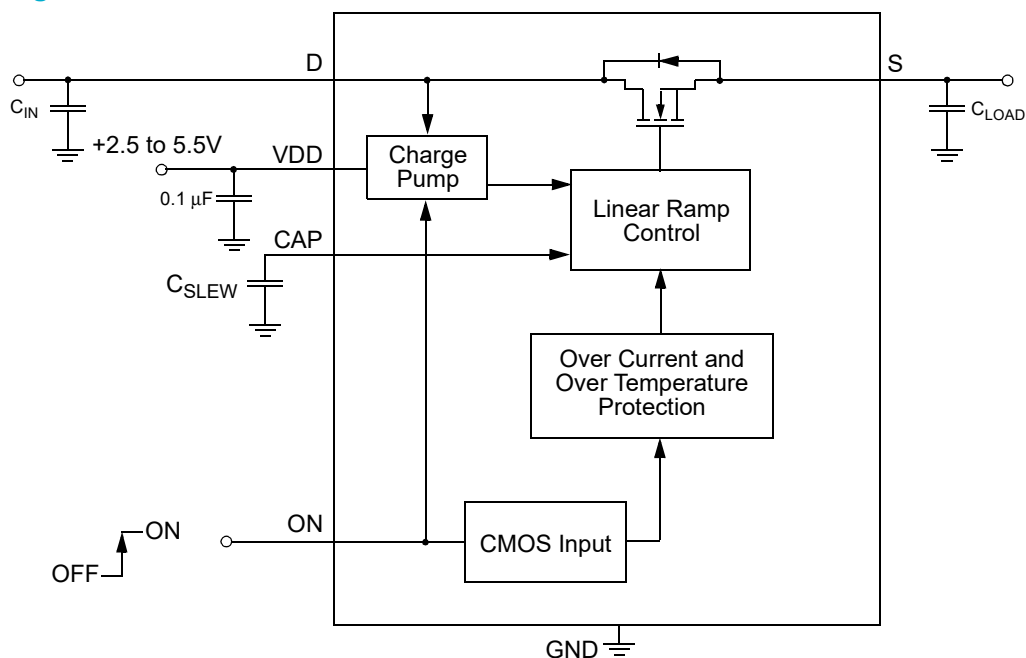
### Pin Configuration



### Applications

- Notebook Power Rail Switching
- Tablet Power Rail Switching
- Smartphone Power Rail Switching

### Block Diagram



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### Pin Description

Pin #	Pin Name	Type	Pin Description
A1	VDD	PWR	V <sub>DD</sub> power for load switch control (2.5 V to 5.5 V)
B1	ON	Input	Turns MOSFET ON (4 MΩ pull down resistor) CMOS input with ON_V <sub>IL</sub> < 0.3 V, ON_V <sub>IH</sub> > 0.85 V
C1	D	MOSFET	Drain of Power MOSFET (fused with pin D1)
D1	D	MOSFET	Drain of Power MOSFET (fused with pin C1)
D2	S	MOSFET	Source of Power MOSFET (fused with pin C2)
C2	S	MOSFET	Source of Power MOSFET (fused with pin D2)
B2	CAP	Input	Capacitor for controlling power rail ramp rate
A2	GND	GND	Ground

### Ordering Information

Part Number	Type	Production Flow
SLG59M1735C	WLCSP 8L	Industrial, -40 °C to 85 °C
SLG59M1735CTR	WLCSP 8L (Tape and Reel)	Industrial, -40 °C to 85 °C

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### Absolute Maximum Ratings

Parameter	Description	Conditions	Min.	Typ.	Max.	Unit
V <sub>DD</sub>	Power Supply		--	--	7	V
T <sub>S</sub>	Storage Temperature		-65	--	150	°C
T <sub>O</sub>	Operating Temperature		-40	--	85	°C
T <sub>A</sub>	Rated Operating Temperature		-40	--	85	°C
ESD <sub>HBM</sub>	ESD Protection	Human Body Model	2000	--	4	V
ESD <sub>CDM</sub>	ESD Protection	Charged Device Model	500	--	6	V
MSL	Moisture Sensitivity Level		1			
θ <sub>JA</sub>	Package Thermal Resistance, Junction-to-Ambient	0.96mm x 1.56mm WLCSP; Determined using 1 in <sup>2</sup> , 1 oz. copper pads under each VD and VS on FR4 pcb material	--	100	--	°C/W
W <sub>DIS</sub>	Package Power Dissipation		--	--	1	W
I <sub>DS</sub> <sub>MAX</sub>	Max Continuous Switch Current		--	--	4	A
MOSFET I <sub>DS</sub> <sub>PK</sub>	Peak Current from Drain to Source	Maximum pulsed switch current, pulse width < 1 ms, 1% duty cycle	--	--	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

T<sub>A</sub> = -40 °C to 85 °C (unless otherwise stated)

Parameter	Description	Conditions	Min.	Typ.	Max.	Unit	
V <sub>DD</sub>	Power Supply Voltage	-40 to 85°C	2.5	--	5.5	V	
I <sub>DD</sub>	Power Supply Current	when OFF	--	0.04	2	μA	
		when ON	--	77	110	μA	
R <sub>DS</sub> <sub>ON</sub>	ON Resistance	T <sub>A</sub> 25°C, I <sub>DS</sub> = 100 mA; V <sub>DD</sub> = V <sub>D</sub> = 5 V	--	10.5	12.1	mΩ	
		T <sub>A</sub> 85°C, I <sub>DS</sub> = 100 mA; V <sub>DD</sub> = V <sub>D</sub> = 5 V	--	12.7	14.3	mΩ	
V <sub>D</sub>	Drain Voltage		0.9	--	V <sub>DD</sub>	V	
I <sub>FET_OFF</sub>	MOSFET OFF Leakage Current	2.5V ≤ V <sub>DD</sub> ≤ 5.5V; V <sub>D</sub> = 4.35V, V <sub>S</sub> = 0V; ON = LOW; T <sub>A</sub> = 25°C	--	0.03	1	μA	
I <sub>LIMIT</sub>	Active Current Limit	MOSFET will automatically limit current when V <sub>S</sub> > 250 mV	4.5	6.0	8	A	
	Short Circuit Current Limit	MOSFET will automatically limit current when V <sub>S</sub> < 250 mV	--	0.5	--	A	
T <sub>ON_Delay</sub>	ON Delay Time	50% ON to 10% V <sub>S</sub> ↑; V <sub>DD</sub> = V <sub>D</sub> = 5 V; R <sub>LOAD</sub> = 20 Ω, C <sub>LOAD</sub> = 10 μF	--	220	400	μs	
V <sub>S(SR)</sub>	Slew Rate	10% V <sub>S</sub> to 90% V <sub>S</sub> ↑; Example: 10% V <sub>S</sub> to 90% V <sub>S</sub> ↑; V <sub>DD</sub> = V <sub>D</sub> = 5 V; C <sub>SLEW</sub> = 3.9 nF, R <sub>LOAD</sub> = 20 Ω, C <sub>LOAD</sub> = 10 μF	Set by External C <sub>SLEW</sub> <sup>1</sup>	2.2	2.8	3.5	V/ms
		50% ON to 90% V <sub>S</sub> ↑; Example: 50% ON to 90% V <sub>S</sub> ↑; V <sub>DD</sub> = V <sub>D</sub> = 5 V; C <sub>SLEW</sub> = 3.9 nF, R <sub>LOAD</sub> = 20 Ω, C <sub>LOAD</sub> = 10 μF	Set by External C <sub>SLEW</sub> <sup>1</sup>	1.5	1.9	2.3	ms

# SLG59M1735C

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### Electrical Characteristics (continued)

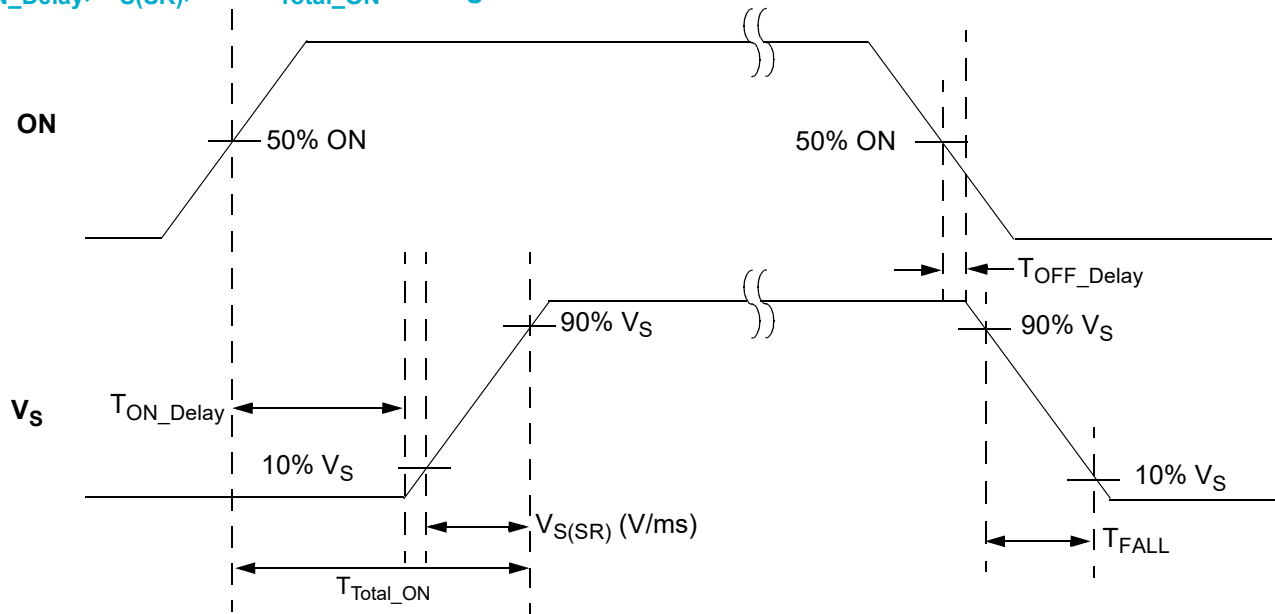
T<sub>A</sub> = -40 °C to 85 °C (unless otherwise stated)

Parameter	Description	Conditions	Min.	Typ.	Max.	Unit
T <sub>OFF_Delay</sub>	OFF Delay Time	50% ON to V <sub>S</sub> ↓; V <sub>DD</sub> = V <sub>D</sub> = 5 V, R <sub>LOAD</sub> = 20 Ω, no C <sub>LOAD</sub>	--	23	--	μs
C <sub>LOAD</sub>	Output Load Capacitance	C <sub>LOAD</sub> connected from V <sub>S</sub> to GND	--	--	500	μF
ON_V <sub>IH</sub>	High Input Voltage on ON pin		0.85	--	V <sub>DD</sub>	V
ON_V <sub>IL</sub>	Low Input Voltage on ON pin		-0.3	0	0.3	V
THERM <sub>ON</sub>	Thermal shutoff turn-on temperature		--	125	--	°C
THERM <sub>OFF</sub>	Thermal shutoff turn-off temperature		--	100	--	°C

Notes:

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

### T<sub>ON\_Delay</sub>, V<sub>S(SR)</sub>, and T<sub>Total\_ON</sub> Timing Details



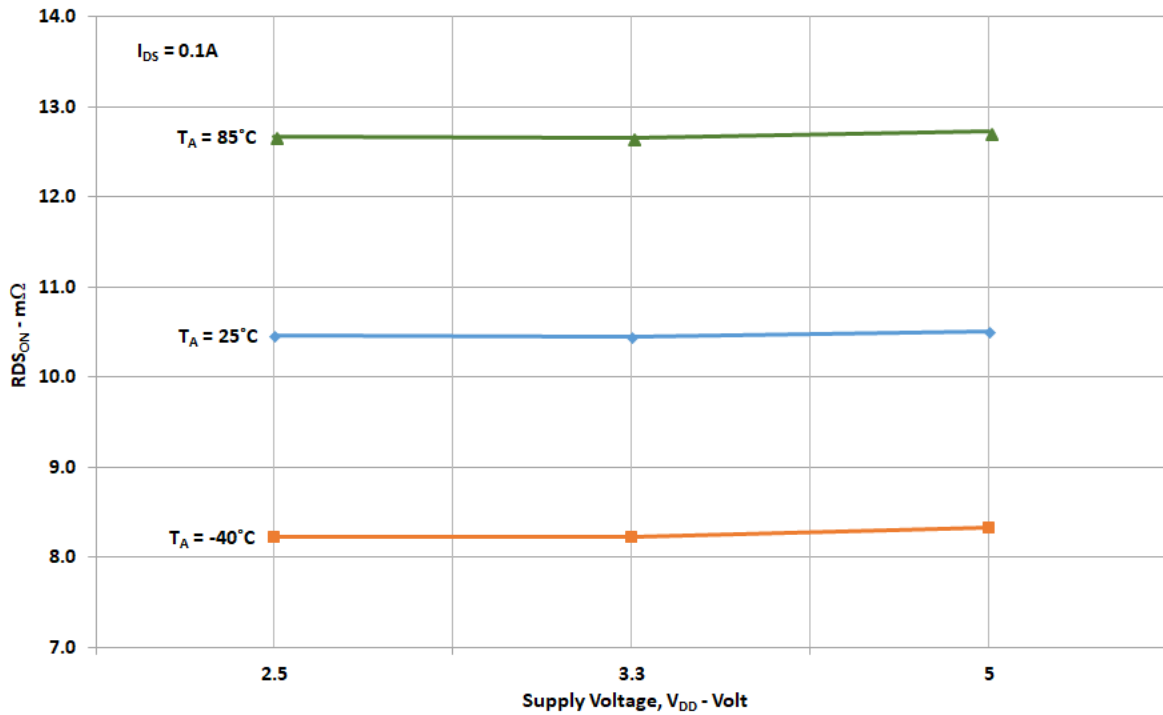
Note: Rise and Fall times of the ON signal are 100 ns

# SLG59M1735C

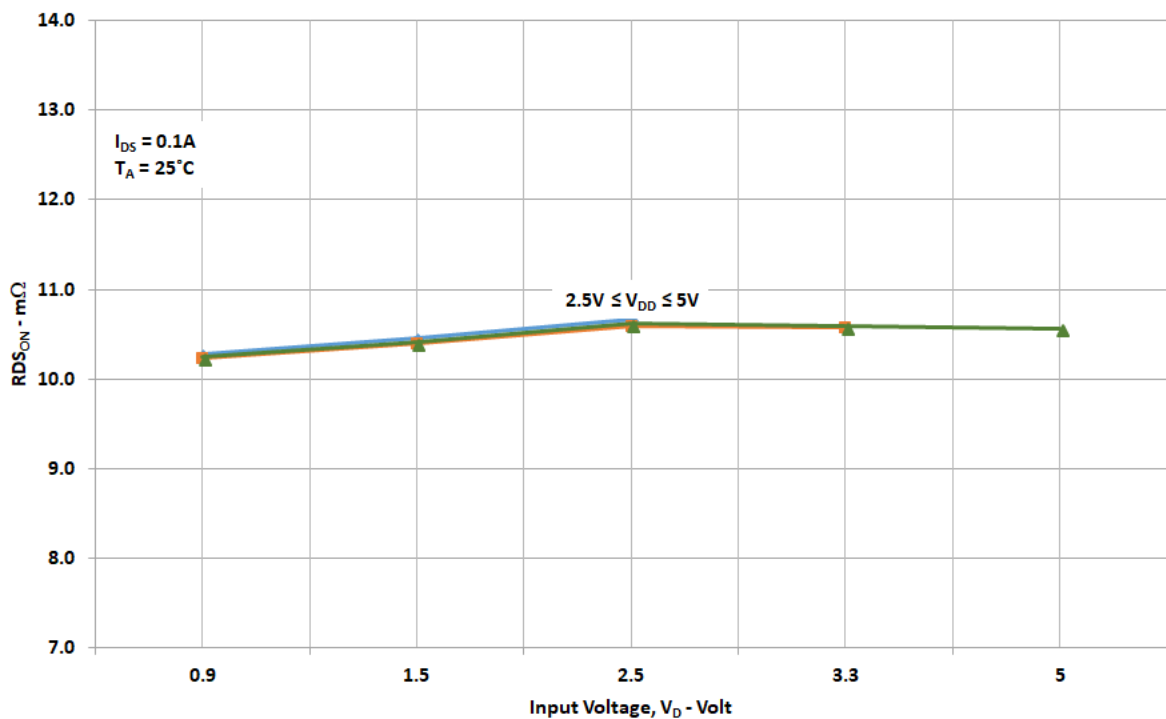
A 10.5 mΩ, 4 A Load Switch  
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## Typical Performance Characteristics

### RDS<sub>ON</sub> vs. V<sub>DD</sub> and Temperature



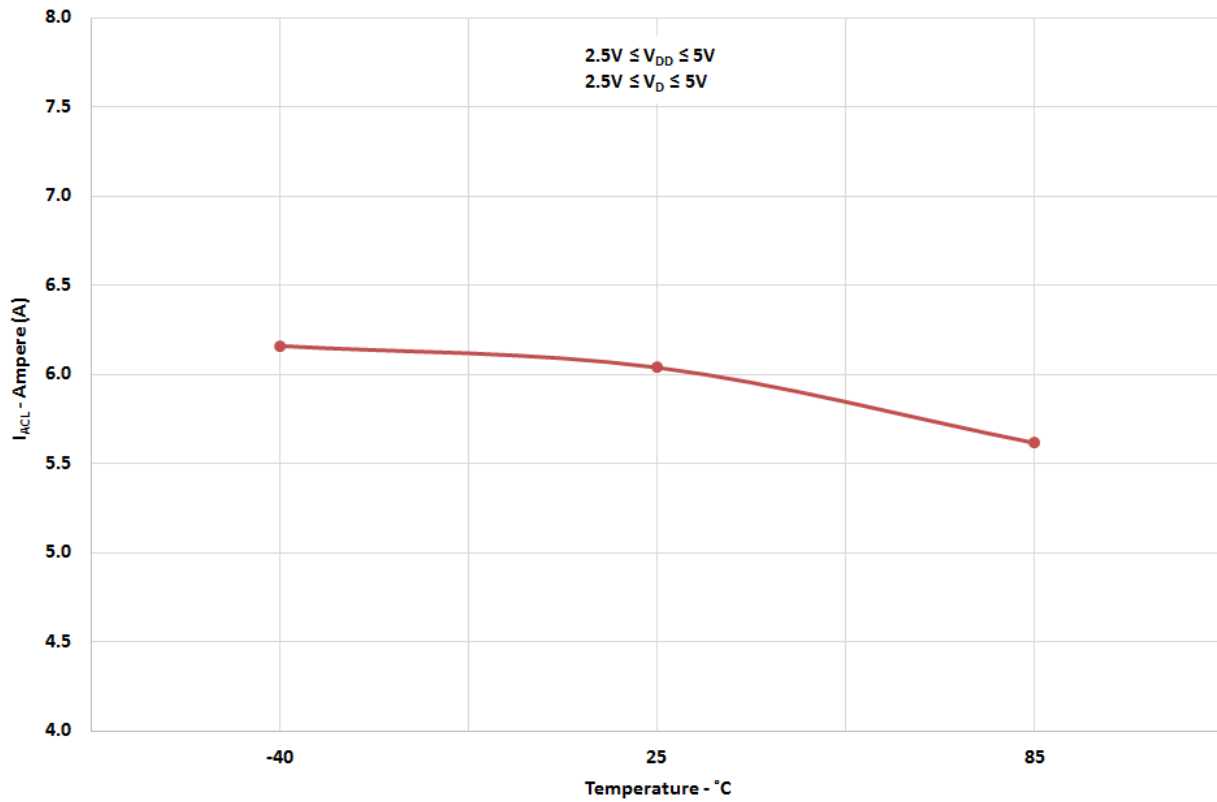
### RDS<sub>ON</sub> vs. V<sub>D</sub> and V<sub>DD</sub>



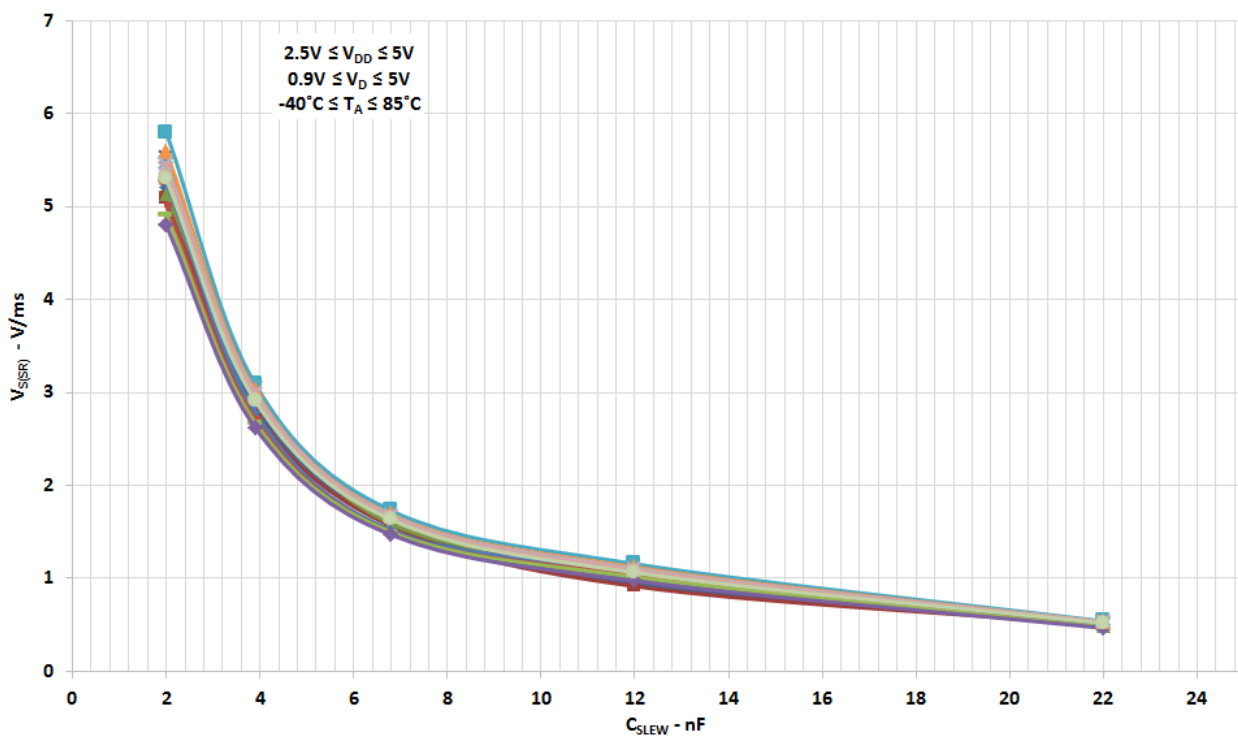
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## I<sub>ACL</sub> vs. Temperature, V<sub>DD</sub>, and V<sub>D</sub>



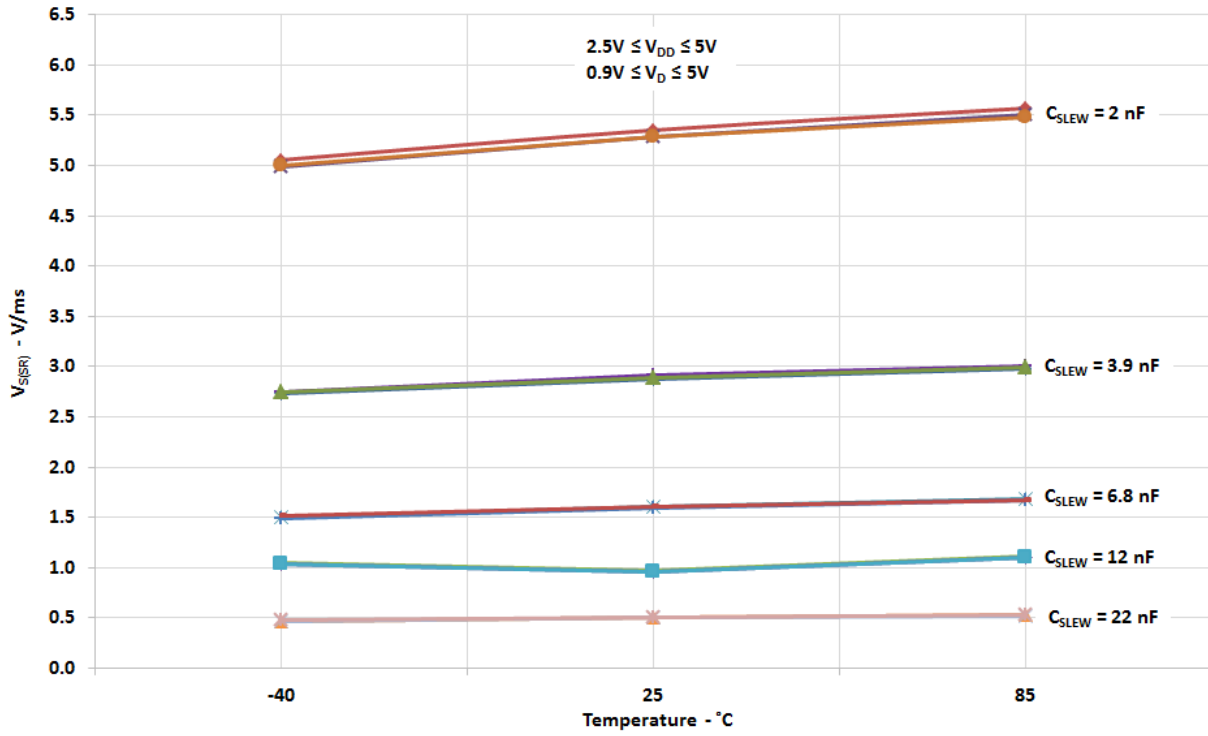
## V<sub>OUT</sub> Slew Rate vs. C<sub>SLEW</sub>, V<sub>DD</sub>, and Temperature



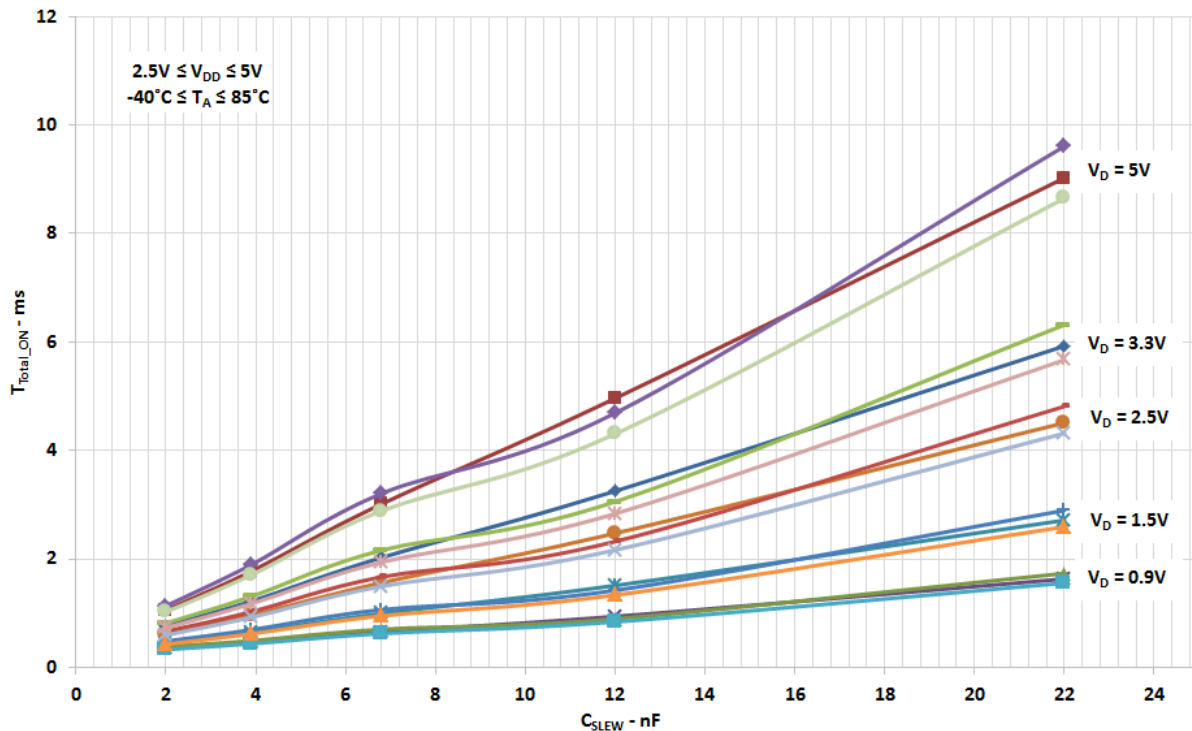
# SLG59M1735C

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## V<sub>OUT</sub> Slew Rate vs. Temperature, V<sub>DD</sub>, and C<sub>SLEW</sub>



## T<sub>Total\_ON</sub> vs. C<sub>SLEW</sub>, V<sub>D</sub>, and V<sub>DD</sub>



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Typical Turn-on Waveforms -  $V_{DD} = V_D = 5\text{ V}$

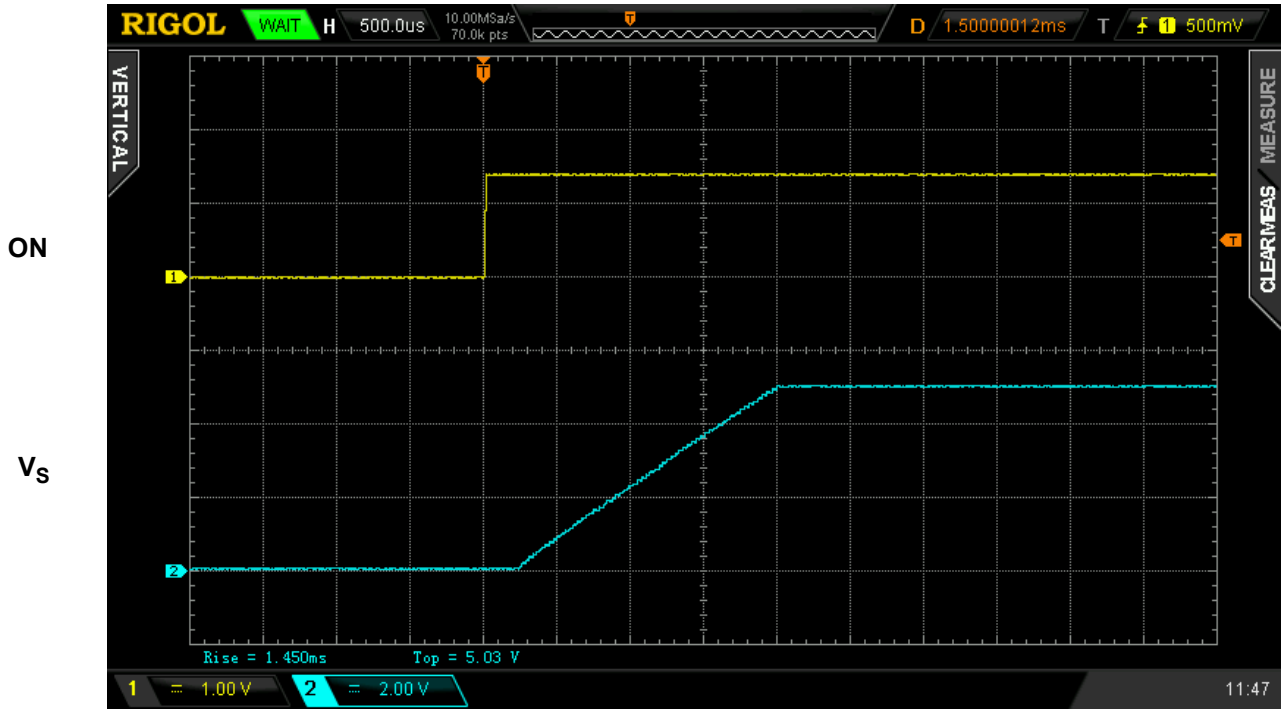


Figure 1. Typical Turn ON operation waveform for  $V_{DD} = V_D = 5\text{ V}$ ,  $C_{SLEW} = 4\text{ nF}$ ,  $C_{LOAD} = 10\text{ }\mu\text{F}$ ,  $R_{LOAD} = 20\text{ }\Omega$

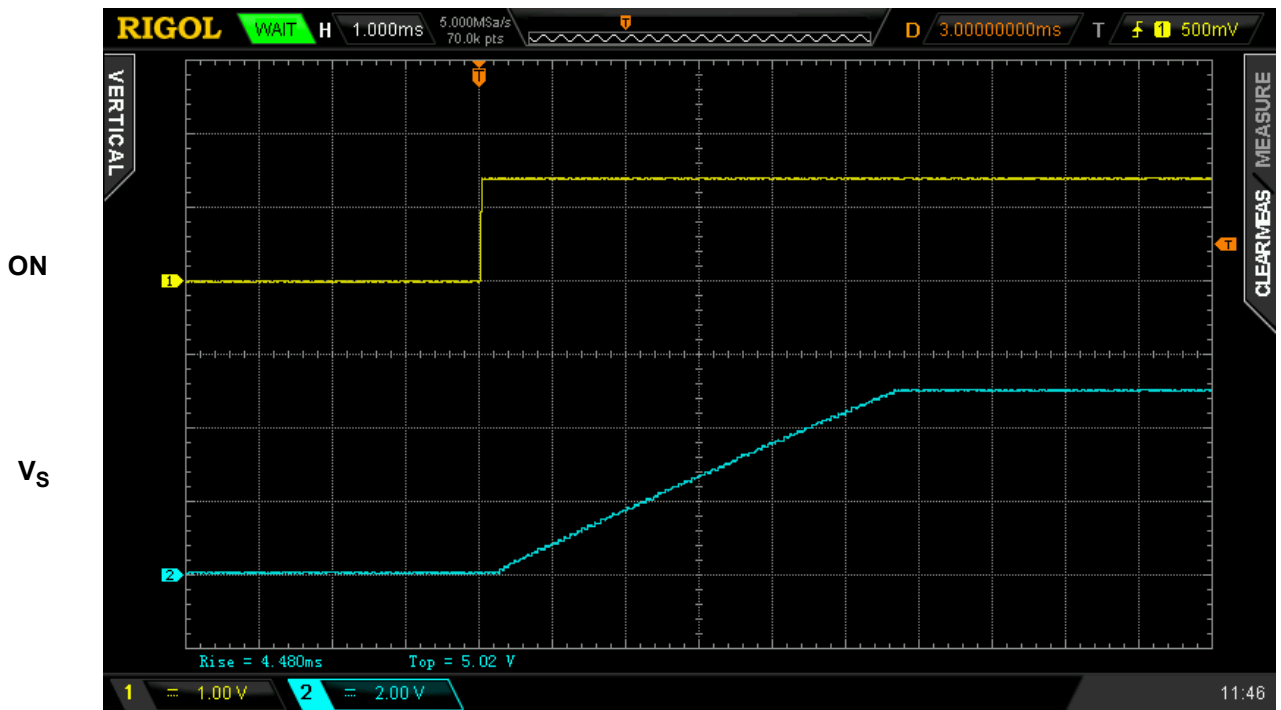


Figure 2. Typical Turn ON operation waveform for  $V_{DD} = V_D = 5\text{ V}$ ,  $C_{SLEW} = 12\text{ nF}$ ,  $C_{LOAD} = 10\text{ }\mu\text{F}$ ,  $R_{LOAD} = 20\text{ }\Omega$



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Typical Turn-off Waveforms -  $V_{DD} = V_D = 5\text{ V}$

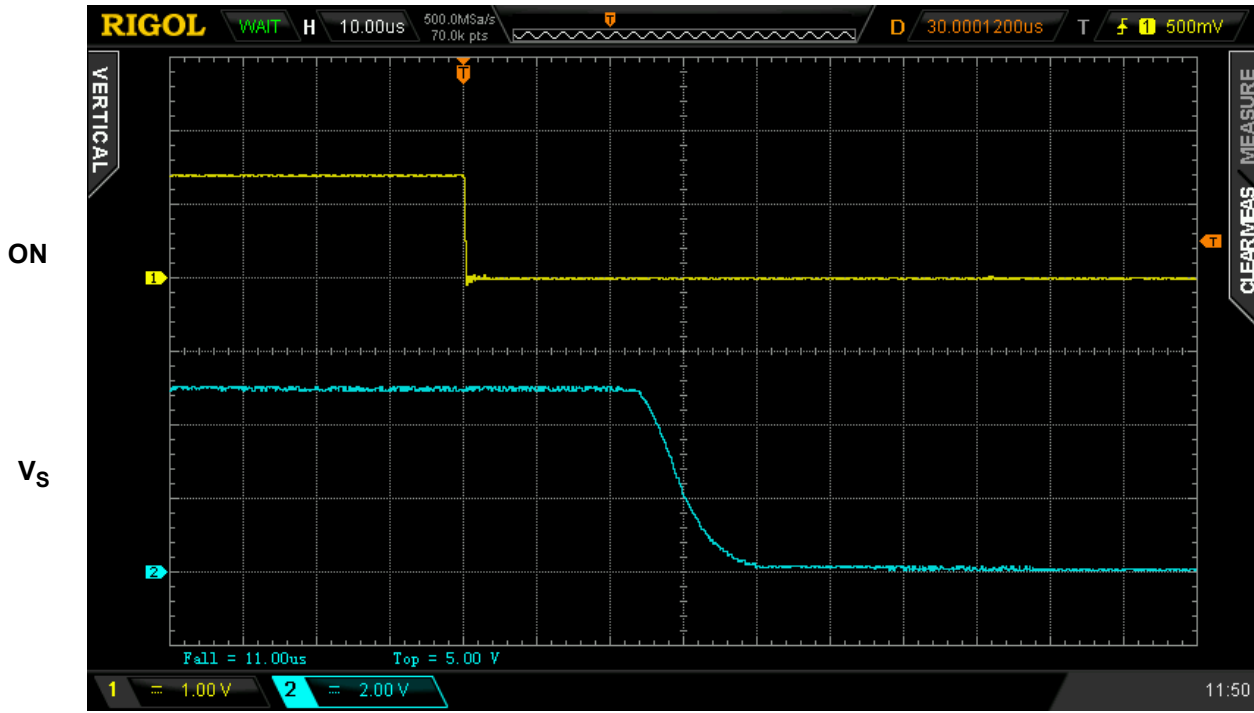


Figure 3. Typical Turn OFF operation waveform for  $V_{DD} = V_D = 5\text{ V}$ ,  $C_{SLEW} = 4\text{ nF}$ , no  $C_{LOAD}$ ,  $R_{LOAD} = 20\ \Omega$



Figure 4. Typical Turn OFF operation waveform for  $V_{DD} = V_D = 5\text{ V}$ ,  $C_{SLEW} = 4\text{ nF}$ ,  $C_{LOAD} = 10\ \mu\text{F}$ ,  $R_{LOAD} = 20\ \Omega$

## SLG59M1735C

### A 10.5 mΩ, 4 A Load Switch with Soft-start and Protection Features in WLCSP

#### SLG59M1735C Power-Up/Power-Down Sequence Considerations

To ensure glitch-free power-up under all conditions, apply  $V_{DD}$  first, followed by  $V_D$  after  $V_{DD}$  exceeds 1 V. Then allow  $V_D$  to reach 90% of its max value before toggling the ON pin from Low-to-High. Likewise, power-down in reverse order.

If  $V_{DD}$  and  $V_D$  need to be powered up simultaneously, glitching can be minimized by having a suitable load capacitor. A 10  $\mu$ F  $C_{LOAD}$  will prevent glitches for rise times of  $V_{DD}$  and  $V_D$  higher than 2 ms.

If the ON pin is toggled HIGH before  $V_{DD}$  and  $V_D$  have reached their steady-state values, the load switch timing parameters may differ from datasheet specifications.

The slew rate of output  $V_S$  follows a linear ramp set by a capacitor connected to the CAP pin. A larger capacitor value at the CAP pin produces a slower ramp, reducing inrush current from capacitive loads.

#### SLG59M1735C Voltage Limitation

$V_D$  may not exceed  $V_{DD}$  for proper operation otherwise the Active Current Limit cannot function properly.

#### SLG59M1735C Current Limiting

The SLG59M1735C has two modes of current limiting, differentiated by the output (Source pin) voltage.

##### 1. Standard Current Limiting Mode (with Thermal Protection)

When  $V_S > 250$  mV, the output current is initially limited to the Active Current Limit specification given in the Electrical Characteristics table. The current limiting circuit is very fast and responds within a few micro-seconds to sudden loads. When overload is sensed, the current limiting circuit increases the FET resistance to keep the current from exceeding the Active Current Limit.

However, if an overload condition persists, the die temperature rise due to the increased FET resistance while at maximum current can activate Thermal Protection. If the die temperature exceeds the  $THERM_{ON}$  specification, the FET is shut completely OFF, allowing the die to cool. When the die cools to the  $THERM_{OFF}$  temperature, the FET is allowed to turn back on. This process may repeat as long as the overload condition is present.

##### 2. Short Circuit Current Limiting Mode (with Thermal Protection)

When  $V_S < 250$  mV (which is the case with a hard short, such as a solder bridge on the power rail), the current is limited to approximately 500 mA. Thermal Protection is also present, but since the Short Circuit Current Limit is much lower than Standard Current Limit, activation may only occur at higher ambient temperatures.

For more information on GreenFET load switch features, please visit our website and see App Note “AN-1068 GreenFET and High Voltage GreenFET Load Switch Basics”.

## SLG59M1735C

### A 10.5 mΩ, 4 A Load Switch with Soft-start and Protection Features in WLCSP

#### Layout Guidelines:

1. The VDD pin (A1) needs a 0.1μF (or larger) external capacitor to smooth pulses from the power supply. Locate this capacitor as close as possible to the SLG59M1735C's A1 pin.
2. Since the VIN and VOUT 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 5](#), illustrates proper techniques for heat to transfer as efficiently as possible out of the device;
3. To minimize the effects of parasitic trace inductance on normal operation, it is recommended to connect input C<sub>IN</sub> and output C<sub>LOAD</sub> low-ESR capacitors as close as possible to the SLG59M1735C's VIN and VOUT pins;
4. The GND pin should be connected to system analog or power ground plane.

#### SLG59M1735C Evaluation Board:

A GreenFET Evaluation Board for SLG59M1735C is designed according to the statements above and is illustrated on [Figure 5](#). Please note that evaluation board has D\_Sense and S\_Sense pads. They cannot carry high currents and dedicated only for RDS<sub>ON</sub> evaluation.

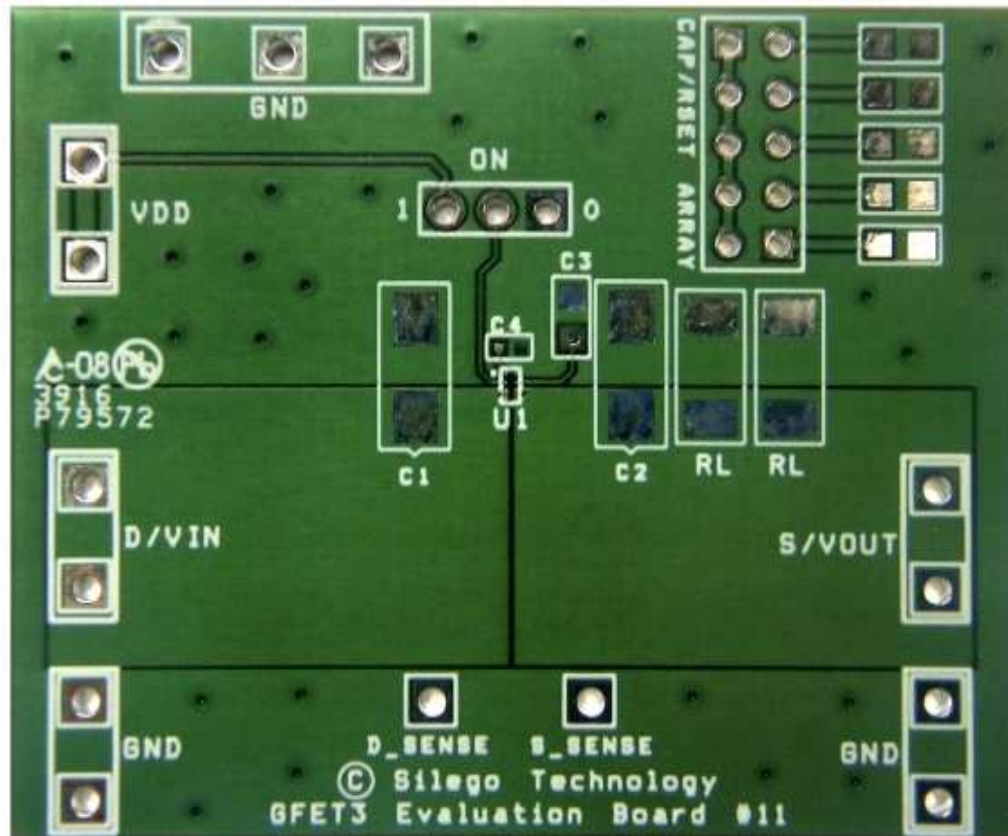
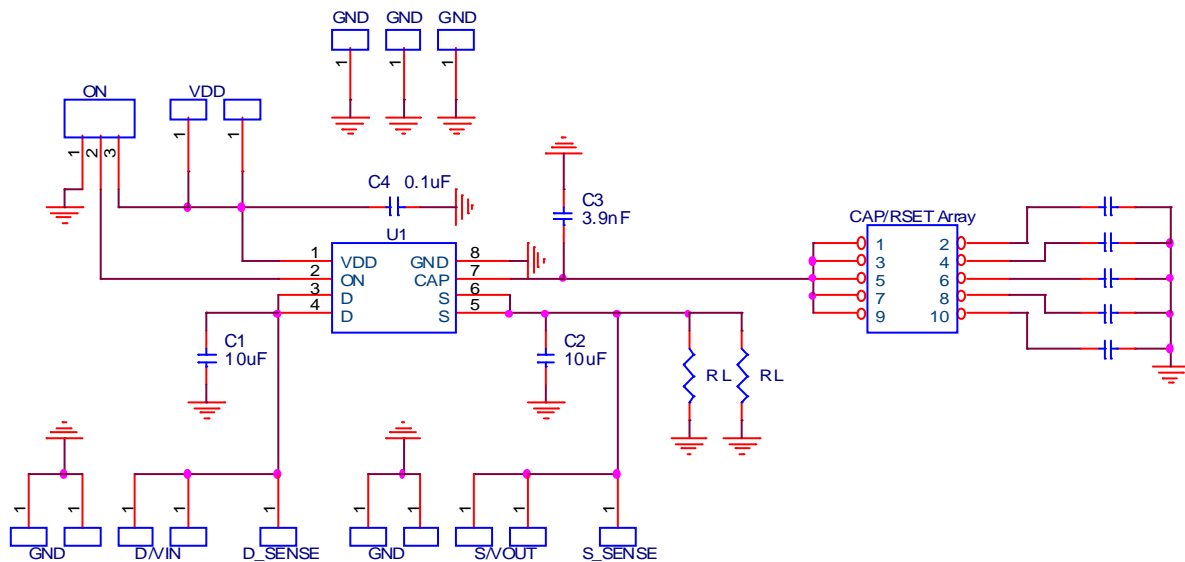


Figure 5. SLG59M1735C Evaluation Board

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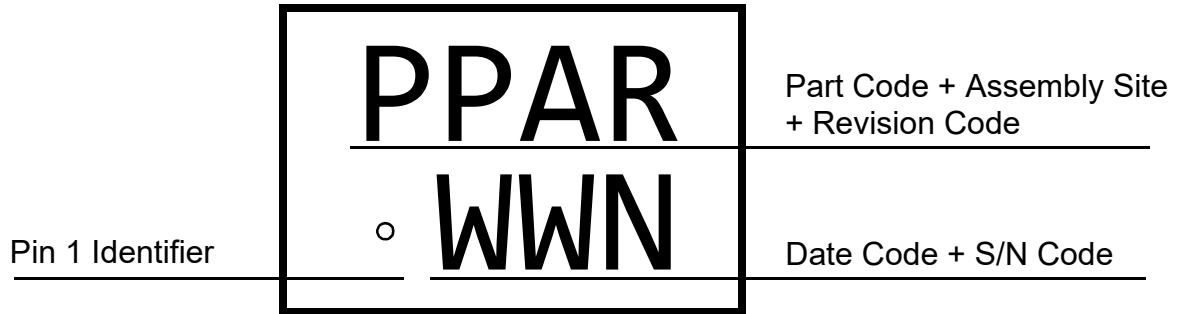
**Figure 6. SLG59M1735C Evaluation Board Connection Circuit**

### Basic EVB Configuration

1. Connect oscilloscope probes to D/VIN, S/VOUT, ON, etc.;
2. Turn on Power Supply 1 and set desired  $V_{DD}$  from 2.5 V...5.5 V range;
3. Turn on Power Supply 2 and set desired  $V_D$  from 0.9 V ...  $V_{DD}$  range;
4. Toggle the ON signal High or Low to observe SLG59M1735C operation.

**SLG59M1735C**

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**Package Top Marking System Definition**

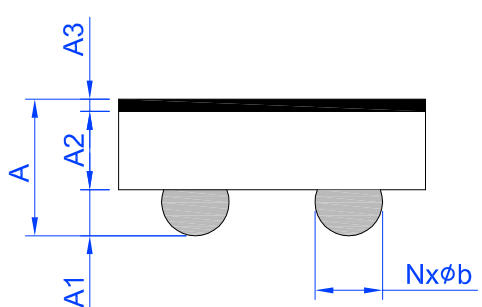
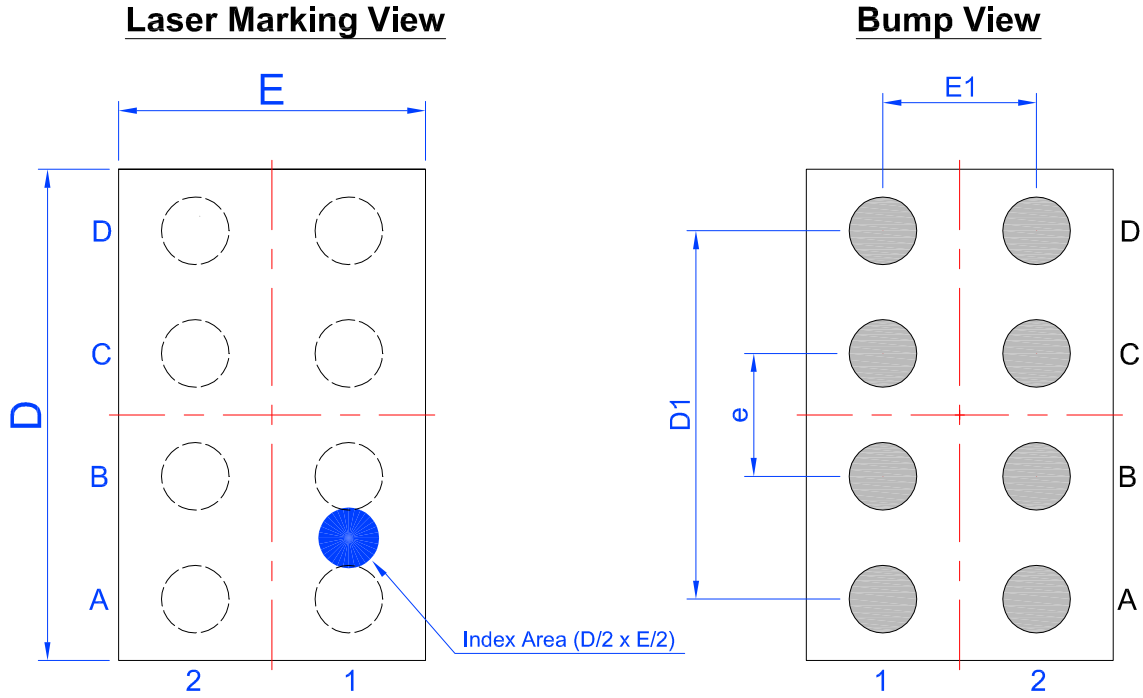
PP - Part Code Field  
A - Assembly Site Code Field  
R - Revision Code Field  
WW - Lot Traceability Field  
N - S/N Code Field

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## Package Drawing and Dimensions

WLCSP 8L 0.96x1.56 mm 0.4P Green Package



PIN No	PIN NAME
A1	VDD
A2	GND
B1	ON
B2	CAP
C1	MOS_D
C2	MOS_S
D1	MOS_D
D2	MOS_S

### SIDE View


Unit: mm

Symbol	Min	Nom.	Max	Symbol	Min	Nom.	Max
A	0.380	-	0.500	D	1.53	1.56	1.59
A1	0.125	0.150	0.175	E	0.93	0.96	0.99
A2	0.240	0.265	0.290	D1	1.20 BSC		
A3	0.015	0.025	0.035	E1	0.50 BSC		
b	0.195	0.220	0.245	e	0.40 BSC		
N	8 (Bump)						

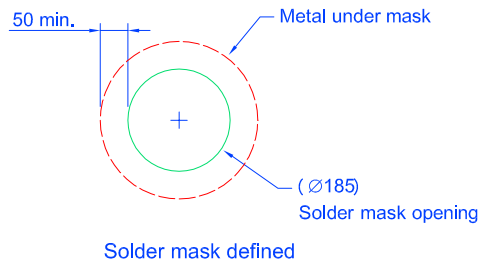
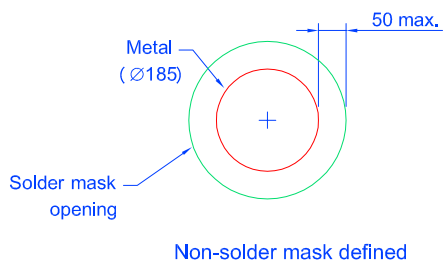
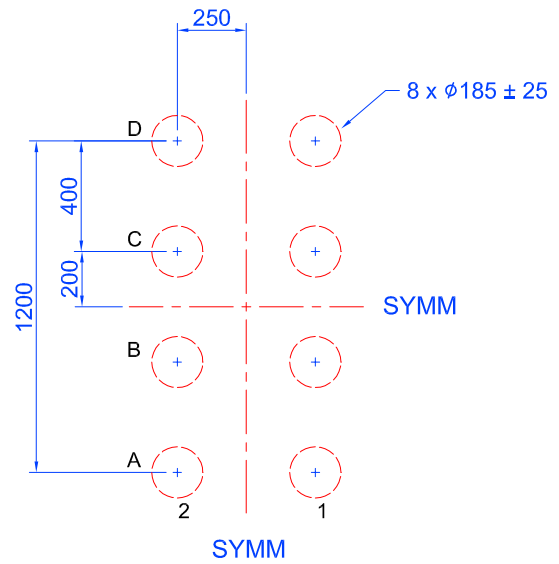
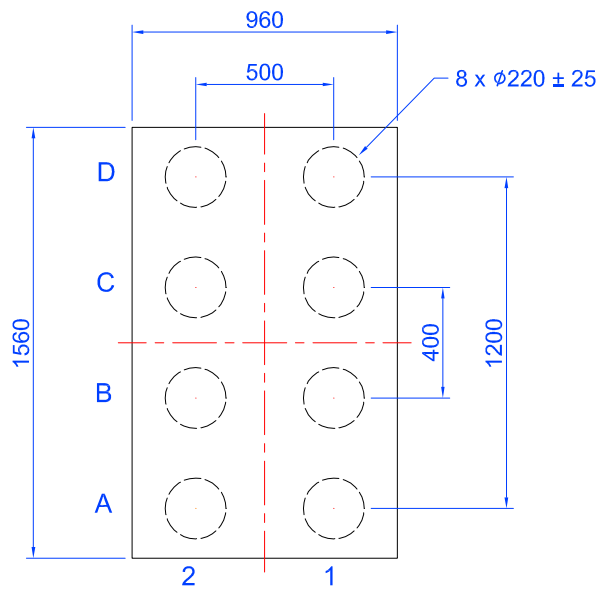
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**SLG59M1735C 8-pin WLCSP PCB Landing Pattern**

 Exposed Bump  
(Laser marking view)

 Recommended  
Land Pattern



Solder mask detail (not to scale)

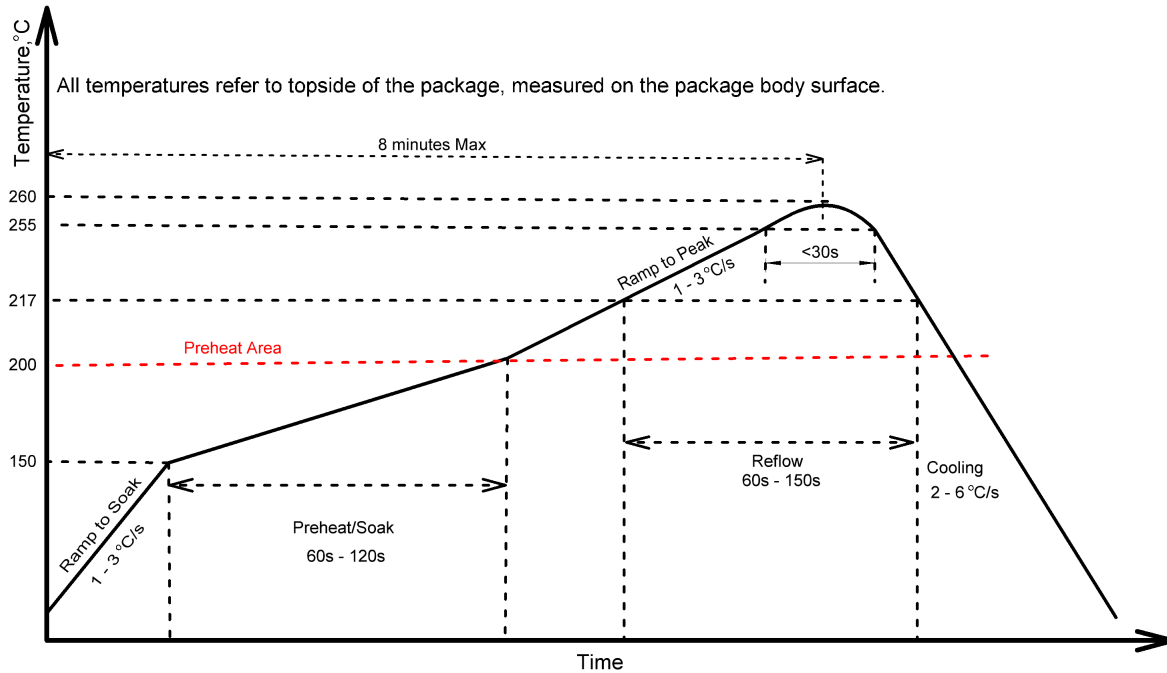
Unit: μm

## SLG59M1735C

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#### Recommended Reflow Soldering Profile

For successful reflow of the SLG59M1735C a recommended thermal profile is illustrated below:



Note: This reflow profile is for classification/preconditioning and are not meant to specify board assembly profile. Actual board assembly profiles should be developed based on specific process needs and board designs and should not exceed parameters depicted on figure above.

Please see more information on IPC/JEDEC J-STD-020: latest revision for reflow profile based on package volume of 0.486 mm<sup>3</sup> (nominal).



## SLG59M1735C

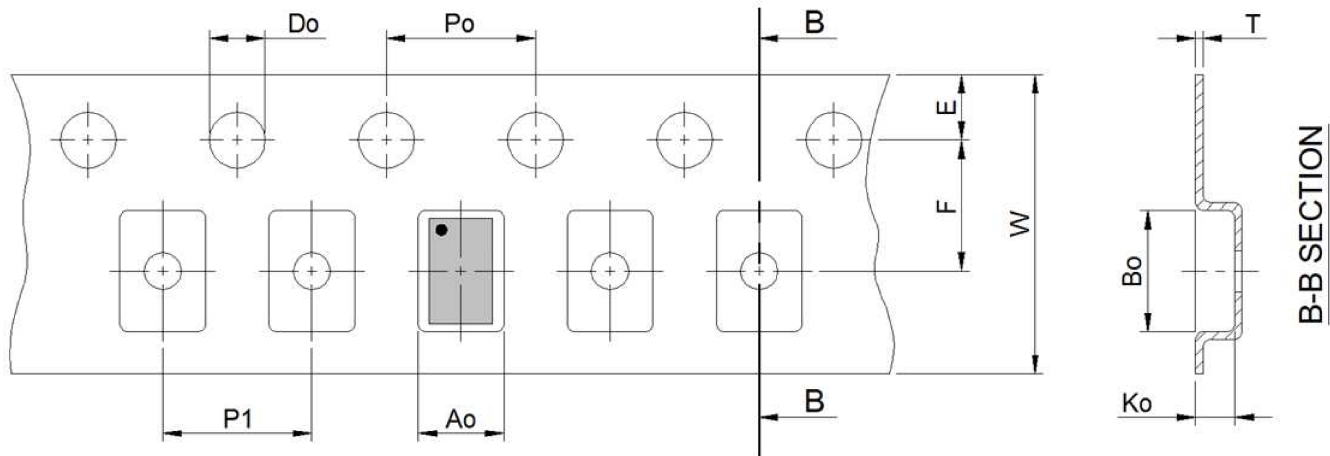
A 10.5 mΩ, 4 A Load Switch  
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### Tape and Reel Specifications

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]		
WLCSP 8L 0.96x1.56 mm 0.4P Green	8	0.96 x 1.56 x 0.44	3000	3000	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	Tape Thickness
	A0	B0	K0	P0	P1	D0	E	F	W	T
WLCSP 8L 0.96x1.56 mm 0.4P Green	1.11	1.7	0.56	4	4	1.5	1.75	3.5	8	0.25



Note: Orientation in carrier: Pin1 is at upper left corner (Quadrant 1).

Refer to EIA-481 specification

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### Revision History

Date	Version	Change
2/4/2022	1.04	Updated Company name and logo Fixed typos Added Layout Guidelines
7/31/2018	1.03	Updated I <sub>DD</sub> spec Updated I <sub>FET_OFF</sub> spec Updated style and formatting
8/11/2017	1.02	Updated Tape and Reel Specs
3/28/2017	1.01	Updated PCB Landing Pattern
2/1/2017	1.00	Production Release

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