

### POWER MANAGEMENT

#### Features

- Input to linear regulator (VIN): 1.0V to 3.6V
- Output (VTT): 0.5V to 1.8V
- Bias Voltage (VDD): 2.35V to 3.6V
- Up to 3A sink or source from VTT for DDR through DDR4
- $\pm 1\%$  over temperature (with respect to VDDQ/2, including internal resistor divider variation) VREF and VTT
- Logic-level enable input
- Built in soft-start
- Thermal shutdown with auto-restart
- Over current protection
- Minimal output capacitance
- Package: MLPD8 - 2mm x 2mm x 0.6mm

#### Applications

- DDR Memory Termination

#### Description

The SC2599 is designed to meet the latest JEDEC specification for low power DDR3 and DDR4, while also supporting DDR and DDR2. The SC2599 regulates up to  $\pm 3A$  for VTT and up to  $\pm 40mA$  for VREF.

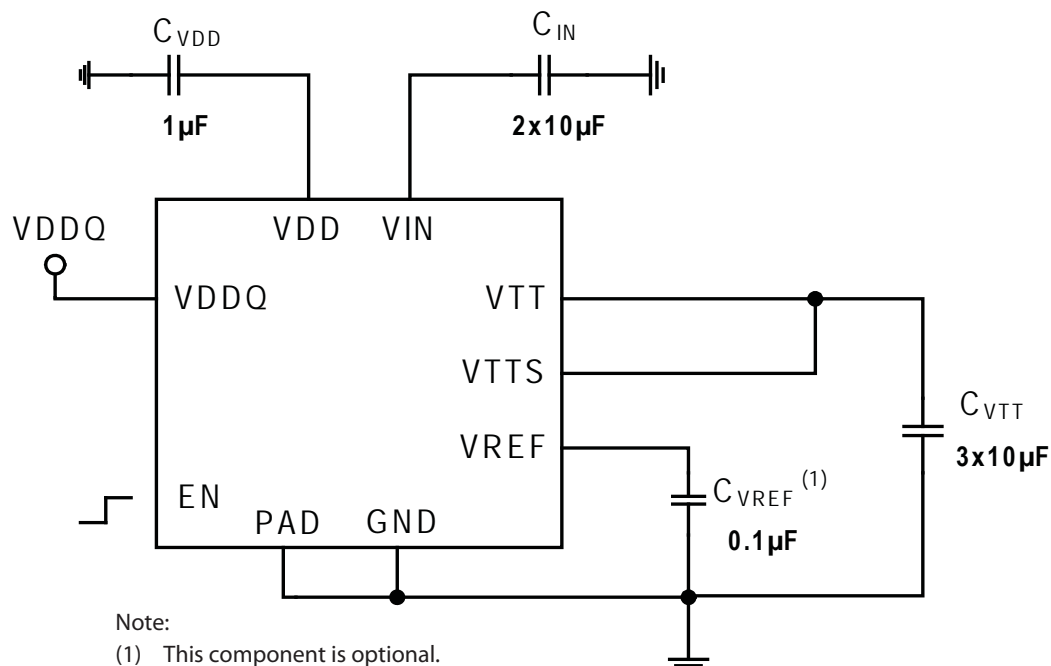
The SC2599 also provides an accuracy of  $\pm 1\%$  over temperature (which takes into account the internal resistor divider) for VREF and VTT for the memory controller and DRAM.

SC2599 protection features include thermal shutdown with auto-restart for VTT and over-current limit for both VTT and VREF.

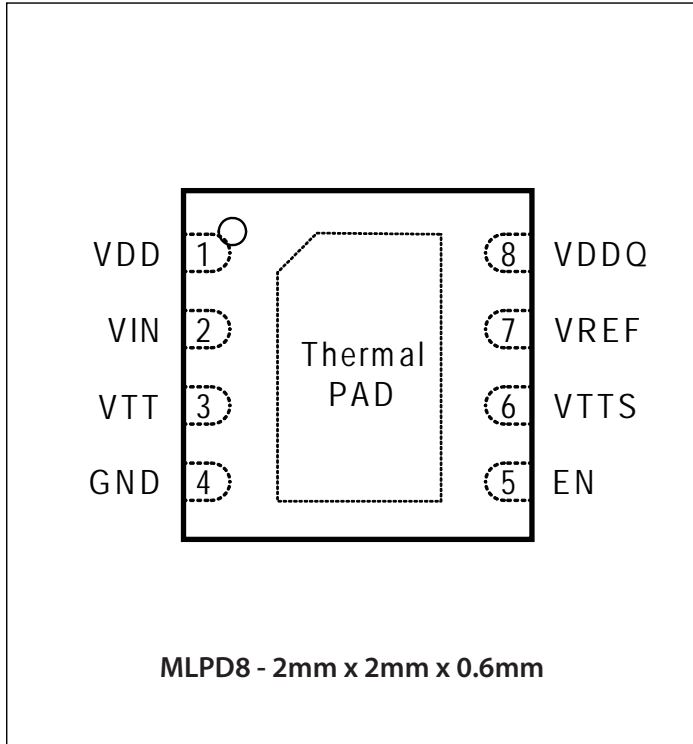
Under-Voltage-Lock-Out circuits are included to ensure that the output is off when the bias voltage falls below its threshold, and that the part behaves elegantly in power-up or power-down.

The low external parts count combined with industry leading specifications make SC2599 an attractive solution for DDR through DDR4 termination.

#### Typical Application Circuit



### Pin Configuration



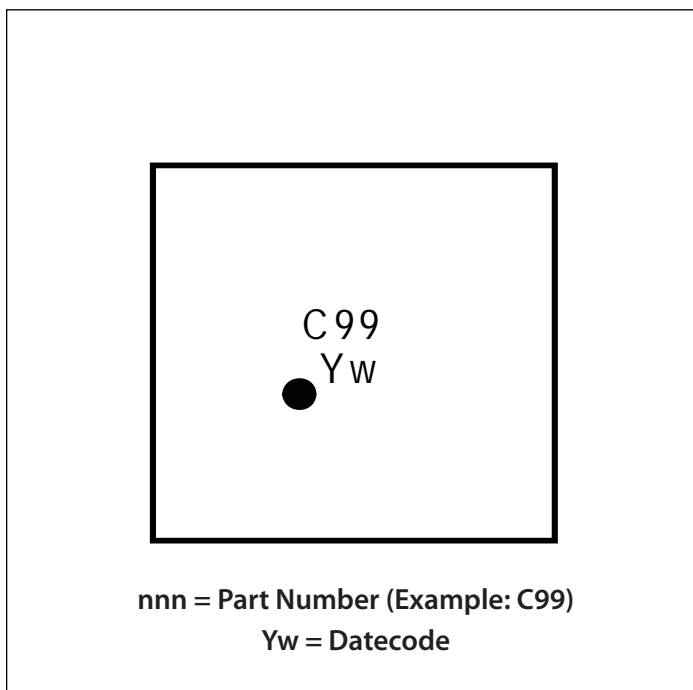
### Ordering Information

Device	Package
SC2599ULTRC <sup>(1)(2)</sup>	MLPD8
SC2599EVB	Evaluation Board

Notes:

- (1) Available in tape and reel only. A reel contains 3000 devices.
- (2) Lead-free packaging only. Device is WEEE and RoHS compliant and halogen-free.

### Marking Information



## Absolute Maximum Ratings

VIN (V).....	-0.3 to 4.3
VDD to GND (V).....	-0.3 to 4.3
VTT to GND (V) .....	-0.3 to VDD
EN (V) .....	-0.3 to 6.0
Other pins .....	-0.3 to 4.3
ESD Protection Level (HBM) <sup>(1)</sup> (kV).....	2.5
ESD Protection Level (CDM) <sup>(1)</sup> (kV).....	1

## Thermal Information

Thermal Resistance, Junction to Ambient <sup>(2)</sup> (°C/W) ...	57
Thermal Resistance, Junction to Ambient <sup>(3)</sup> (°C/W) ...	45
Maximum Junction Temperature (°C) .....	+150
Storage Temperature Range (°C).....	-65 to +150
Peak IR Reflow Temperature (10s to 30s) (°C) .....	+260

Exceeding the above specifications may result in permanent damage to the device or device malfunction. Operation outside of the parameters specified in the Electrical Characteristics section is not recommended.

### Notes:

- (1) HBM: tested according to ANSI/ESDA/JEDEC JS-001. CDM: tested according to JESD-C101E.
- (2) Calculated from package in still air, mounted to 3 x 4.5 (in), 4 layer FR4 PCB with thermal vias under the exposed pad per JESD51 standards.
- (3) Based upon lab measurement on EVB board: 3 x 2 (in), 4 layer FR4 PCB with thermal vias under the exposed pad.

## Electrical Characteristics

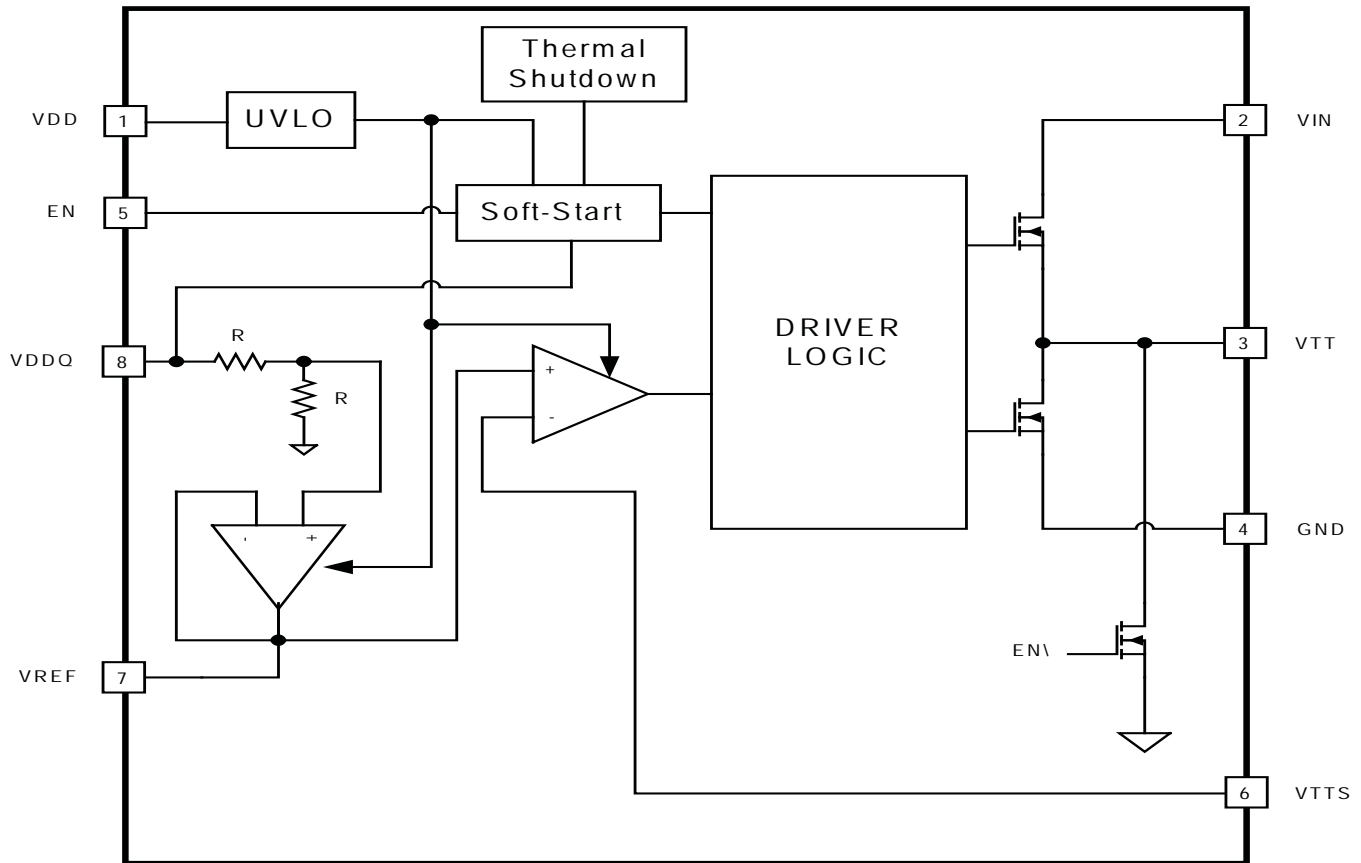
Unless otherwise noted  $T_J = -40$  to  $+125^\circ\text{C}$ ,  $V_{IN} = 1.2\text{V}$ ,  $V_{DD} = 3.3\text{V}$ . Typical values are at  $T_A = 25^\circ\text{C}$ .

Parameter	Symbol	Conditions	Min	Typ	Max	Units
<b>Input Supplies</b>						
LDO Supply Voltage	$V_{IN}$		1		3.6	V
VDD Supply Voltage	$V_{DD}$		2.35		3.6	V
VDD UVLO Threshold		Measured at VDD pin, rising edge	2.0		2.25	V
		Measured at VDD pin, falling edge	1.95		2.15	
VDD UVLO Hysteresis				0.1		V
Quiescent Current for VDD	$I_Q$	Load = 0A, EN = High, $V_{VDDQ} \geq 1\text{V}$		415	700	$\mu\text{A}$
Shutdown Current for VDD	$I_{QSD}$	Load = 0A, EN = Low, $V_{VDDQ} \geq 1\text{V}$ , $I_{REF} = 0\text{A}$		160	400	$\mu\text{A}$
		Load = 0A, EN = Low, $V_{VDDQ} = 0\text{V}$ , $I_{REF} = 0\text{A}$		100	160	$\mu\text{A}$
Quiescent Current for $V_{IN}$	$I_{IN}$	Load = 0A, EN = High		3	30	$\mu\text{A}$
Shutdown Current for $V_{IN}$	$I_{INSD}$	Load = 0A, EN = Low		3	20	$\mu\text{A}$
<b>VTT Output</b>						
Output Voltage Range	VTT		0.5		1.8	V
Output Voltage Tolerance with respect to $VDDQ/2$		Load = 0A, VTT = 0.5V to 1.8V	-1		+1	%

**Electrical Characteristics (continued)**

Parameter	Symbol	Conditions	Min	Typ	Max	Units
Load Regulation		$-2A \leq \text{Load} \leq 2A$	-25		+25	mV
On-Resistance		High-Side MOSFET (source), Load = 0.1A	40	100	150	mΩ
		Low-Side MOSFET (sink), Load = 0.1A	50	140	300	
Discharge MOSFET On-Resistance		EN = Low		8		Ω
<b>Reference Input/Output</b>						
VDDQ Voltage Range			1		3.6	V
VDDQ Input Bias Current			0		10	μA
Tolerance with respect to VDDQ/2		Load = 0A, VREF = 0.5V to 1.8V	-1		1	%
VREF Source Current Limit			40			mA
VREF Sink Current Limit			-40			
<b>Protection</b>						
Thermal Shutdown Threshold				160		°C
Thermal Restart Hysteresis				20		°C
Output Current Limit Threshold		Ambient Temperature: 25 °C	3.7	4.3		A
<b>Soft-Start</b>						
VTT Soft-Start Time		From EN = High to $V_{TT} = 90\% V_{REF}$		40		μs
<b>Logic</b>						
EN Logic Threshold		EN = High	1.7			V
		EN = Low			0.3	
EN Input Current			-1		1	μA

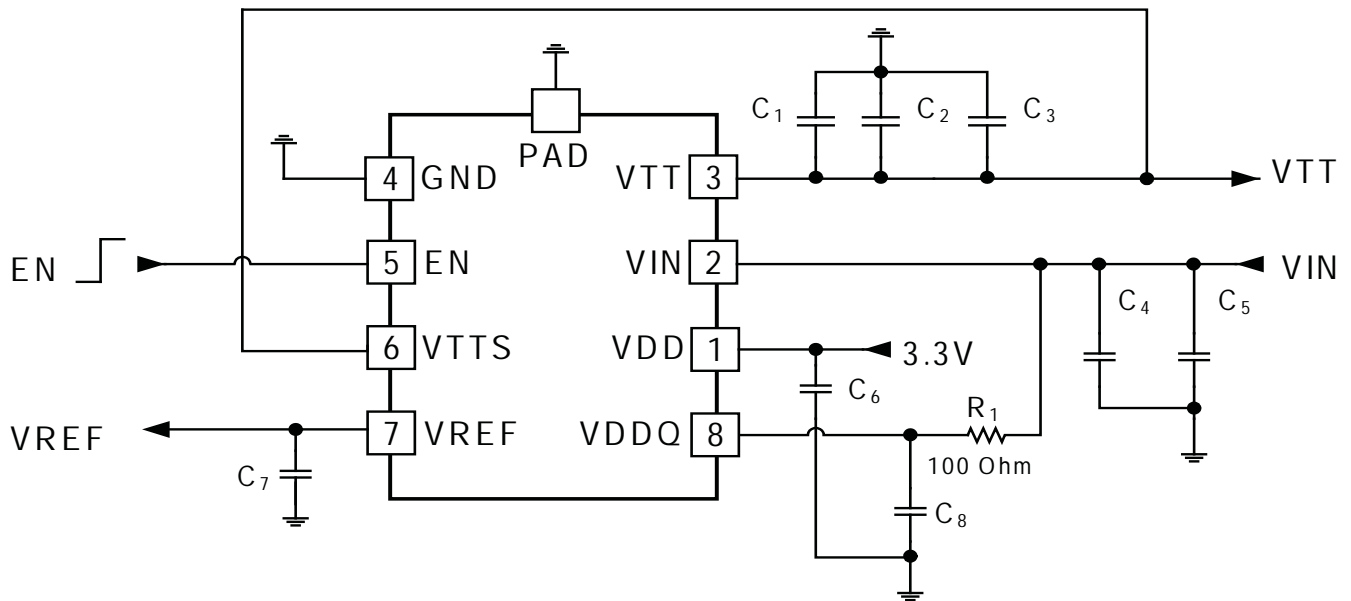
## Block Diagram



## Pin Descriptions

Pin #	Pin Name	Pin Function
1	VDD	Input bias voltage — 2.35V to 3.6V . Connect a ceramic capacitor from this pin to GND.
2	VIN	LDO input range — 1V to 3.6V. Connect ceramic capacitors from this pin to GND.
3	VTT	Output of the linear regulator. Connect ceramic capacitors from this pin to GND.
4	GND	Ground reference for the IC.
5	EN	Logic input to enable or disable the VTT output. If EN pin is grounded to shut down the linear regulator, VREF remains active.
6	VTTS	VTT output sense input. Connect VTTS to the output at the output capacitor to implement remote sense.
7	VREF	The reference output, equal to one half of VDDQ. Connect a 100nF capacitor from this pin to GND.
8	VDDQ	External reference input; range 1V to 3.6V.
PAD	GND	Thermal pad. This pad must be connected to GND. For optimal heat sinking, connect to the GND plane using multiple vias.

### Detailed Application Circuit



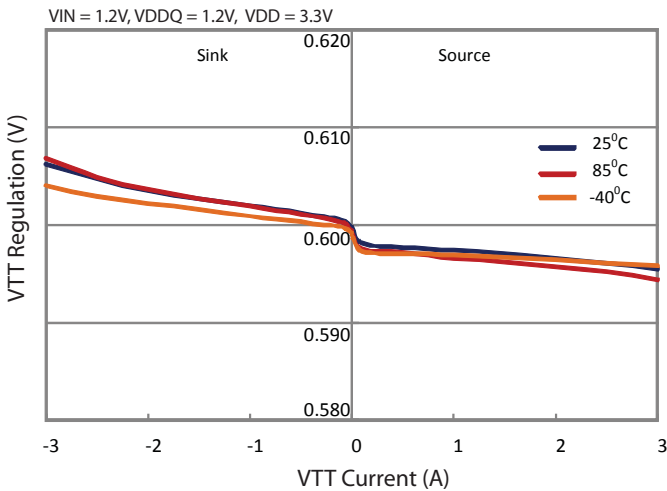
### Bill Of Materials

Reference Designator	Description	Value	Part Number	Manufacture
C <sub>1</sub> , C <sub>2</sub> , C <sub>3</sub> , C <sub>4</sub> , C <sub>5</sub>	Ceramic Capacitor	10uF/0805/X7R	GRM21BR71A106KE51	Murata
C <sub>6</sub>	Ceramic Capacitor	1uF/0603/X7R	GRM188R71A105KA61D	Murata
C <sub>7</sub> , C <sub>8</sub>	Ceramic Capacitor	0.1uF/0603/X7R	GRM188R71H104KA93D	Murata

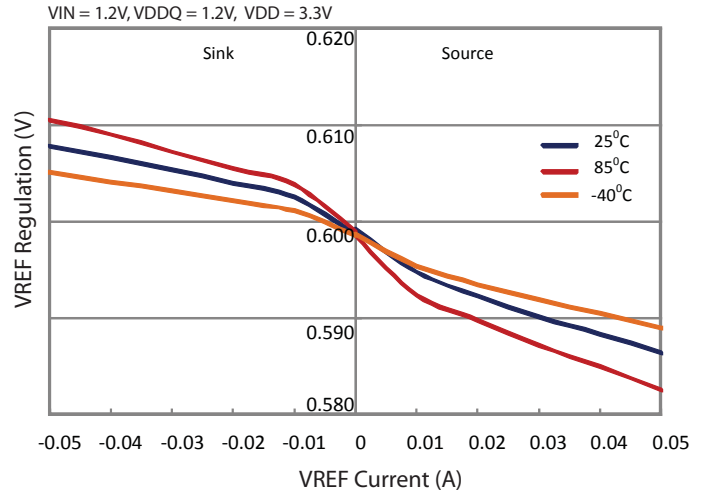
## Typical Characteristics

Characteristics in this section are based upon the detailed application circuit on page 6.

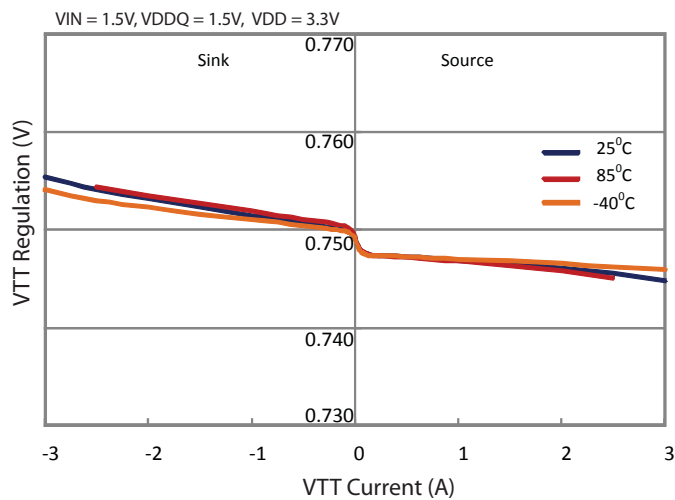
**0.6V VTT Regulation Sink/Source**



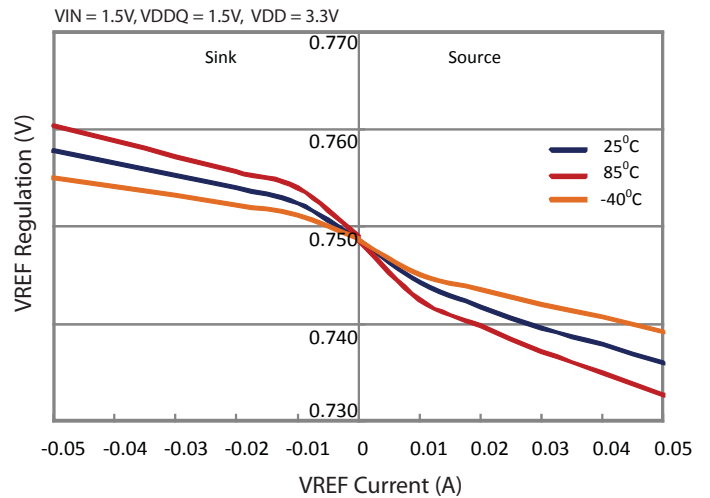
**0.6V VREF Regulation Sink/Source**



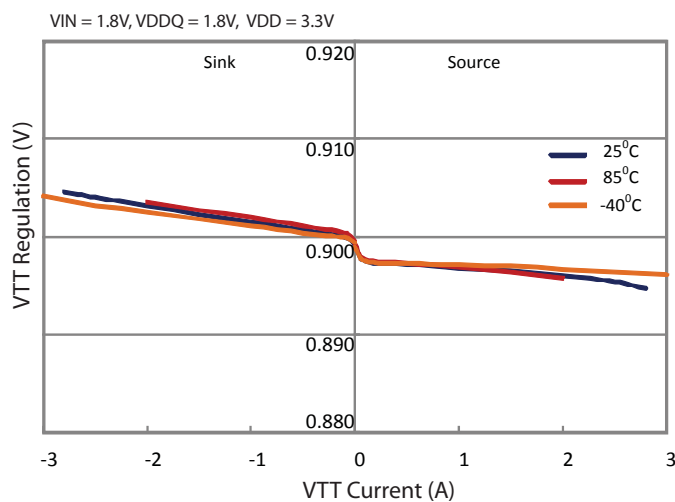
**0.75V VTT Regulation Sink/Source**



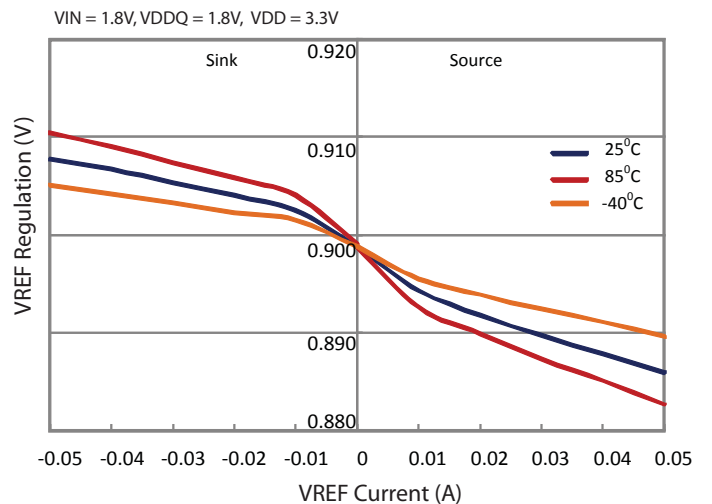
**0.75V VREF Regulation Sink/Source**



**0.9V VTT Regulation Sink/Source**



**0.9V VREF Regulation Sink/Source**

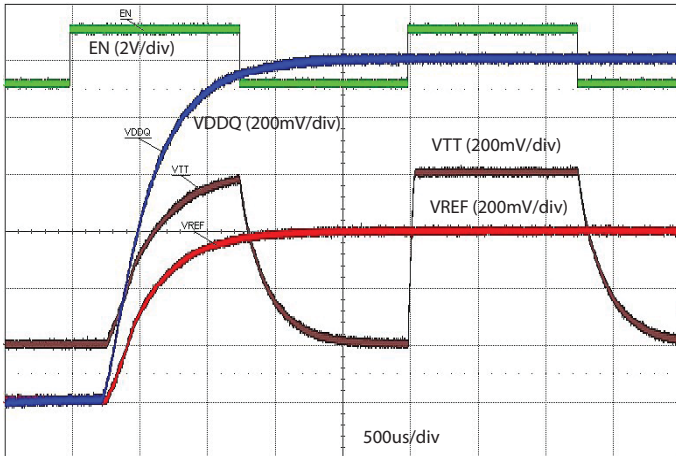


## Typical Characteristics

Characteristics in this section are based upon the detailed application circuit on page 6.

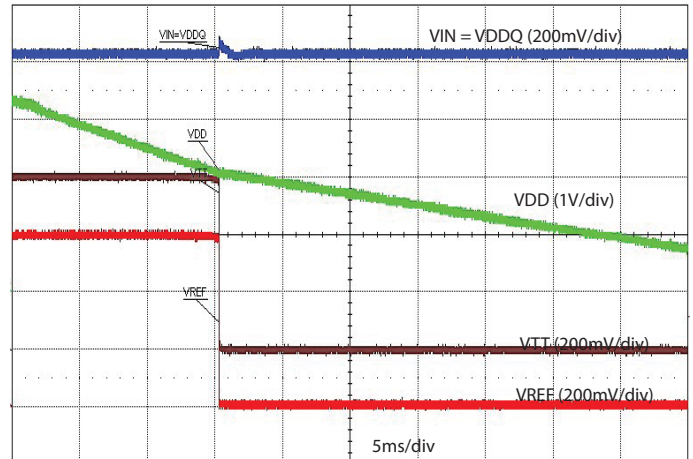
### Start-Up and Shutdown Using EN

VIN = 1.2V, VDD = 3.3V, VREF = 0A, VTT = 0A



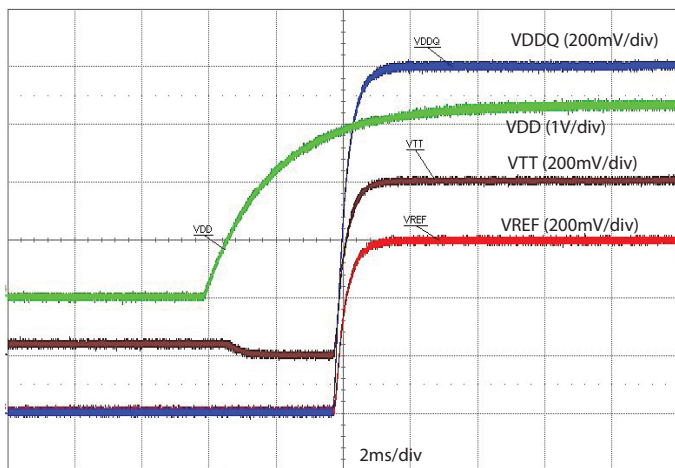
### Shutdown Using VDD

VREF = 40mA, VTT = 1A



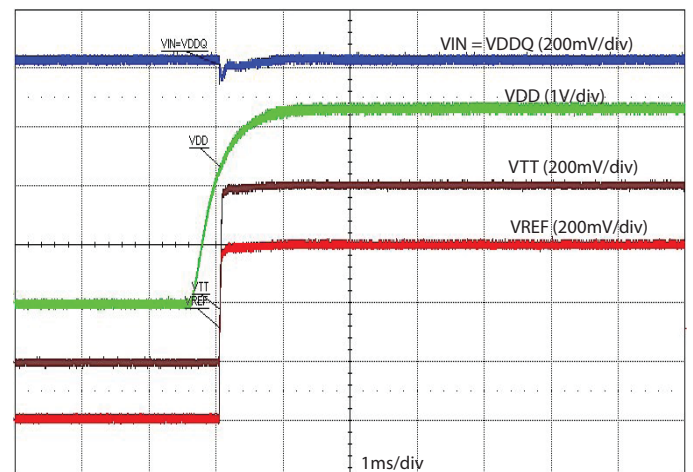
### Start-Up Using VDDQ

VREF = 0A, VTT = 0A, VIN = 1.2V



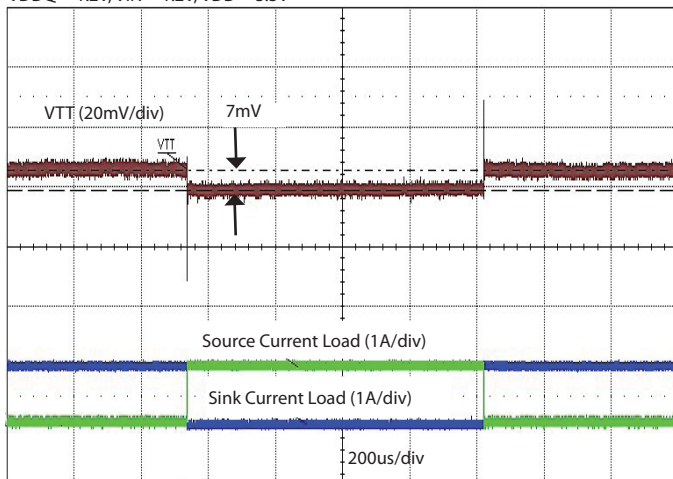
### Start-Up Using VDD

VREF = 40mA, VTT = 1A



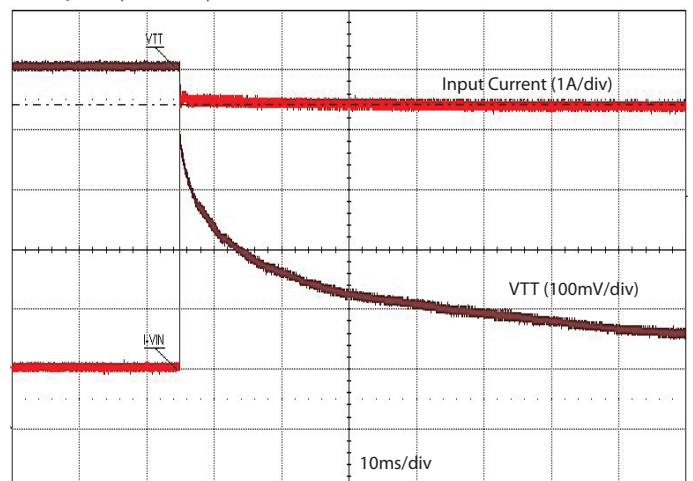
### Load Transient Source and Sink: -1A to +1A

VDDQ = 1.2V, VIN = 1.2V, VDD = 3.3V



### Current Limit with VTT Shorted

VDDQ = 1.2V, VIN = 1.2V, VDD = 3.3V





## Applications Information

### VTT Output

VTT starts to ramp up when EN and VDD meet their startup thresholds. SC2599 regulates VTT to the voltage at VREF and can support up to 3A for sourcing or sinking capability.

To achieve tight regulation and fast dynamic response at VTT, it is recommended to connect the VTTs sense signal to VTT at the ceramic output capacitors.

### VREF Output

VREF starts to ramp up when VDD meets the UVLO threshold. SC2599 regulates VREF to one-half of VDDQ. To reduce the component count and provide a good accuracy reference for VTT, SC2599 includes an internal resistor divider network. SC2599 is capable of sinking or sourcing up to 60mA at VREF. To reduce the component count further, SC2599 does not require the user to have a local ceramic capacitor at the VREF pin - but it is recommended to layout with a capacitor place holder.

### EN Input

The EN pin is used to enable and disable VTT only; it does not control VREF. When EN is pulled low, the VTT output is discharged internally to ground through an 8Ω FET.

### Protection

SC2599 has thermal protection with auto-restart. When the junction temperature is above the thermal shutdown threshold (160°C), SC2599 disables VTT, while VREF remains present. When the junction temperature drops below the hysteretic window, typically at 140°C, SC2599 will be enabled again.

SC2599 has a built-in current limit feature to prevent damage to the sink and source FETs. If VTT is shorted to VDD or ground, SC2599 will sink or source current up to the current limit threshold.

### Input Capacitor

The primary purpose of input capacitance is to provide the charge to the VTT output capacitor when there is a load transient at VTT. In the typical application circuit, VDDQ equals VIN, and VTT equals one-half of VDDQ. As a result,

theory tells us that the input capacitance can be chosen to be half of the output capacitance.

Ceramic capacitors have a capacitance value that degrades with temperature, DC and AC bias, and their chemistry. Usually, ceramic capacitors need to be derated by 50% when operated at their rated DC voltage. Therefore, it is recommended to use capacitors with a voltage rating of 6.3V or higher for 3.3V or lower applications.

### Stability and VTT Capacitor

Figure 1 shows the small signal model for the sourcing current loop stability. The low frequency pole is formed by  $C_{OUT}$  and  $R_L$ . Since this pole depends on those variables, it is recommended to have a minimum of 10uF  $C_{OUT}$  for stable condition. SC2599 has an internal compensation network to ensure the stability as the load changes. Figure 2 shows the bode plot with the crossover frequency at around 0.8MHz and 36 degree phase margin. Another parameter effecting to the loop stability is parasitic inductance in PCB layout and output capacitor ESL. The gain plot shows that a peaking rising after the crossing frequency is due to ESL effect. Minimizing the ESL reduces this peaking.

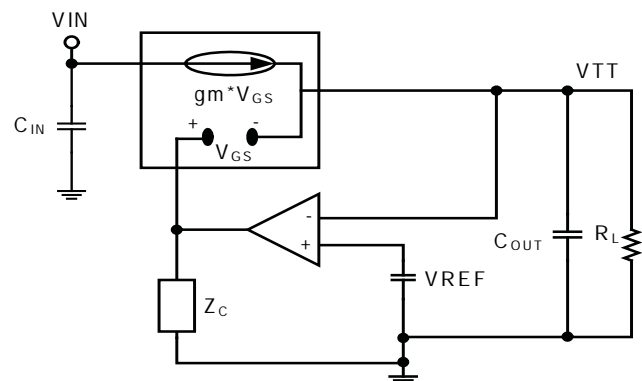


Figure 1 — Small Signal Model

### PCB Layout

The SC2599 requires minimal external components to provide a VTT solution. Figure 3 shows the component placement and layout for the application circuit on page 6. The thermal pad should be connected to the GND plane using multiple vias.



**Figure 2 — Gain and Phase Bode Plot**  
**Fc = 810KHz, PM = 36 degree at 1A Source**

**Critical Layout Guidelines**

Bias and Reference Capacitors:

A 1 $\mu$ F capacitor must be placed as close as possible to the IC and connected between pin 6 (VDD) and the ground plane.

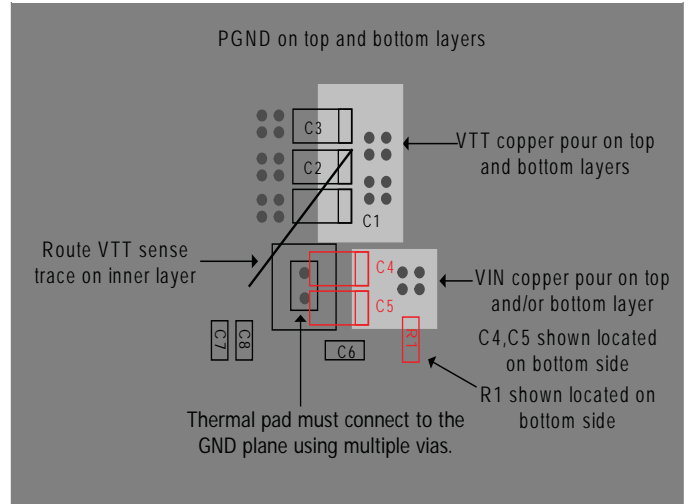
A 0.1 $\mu$ F capacitor must be placed as close as possible to the IC and connected between pin 4 (VREF) and the ground plane. The user has an option to add this capacitor to the circuit but it is recommended to layout with a capacitor place holder.

VDDQ Reference Capacitor:

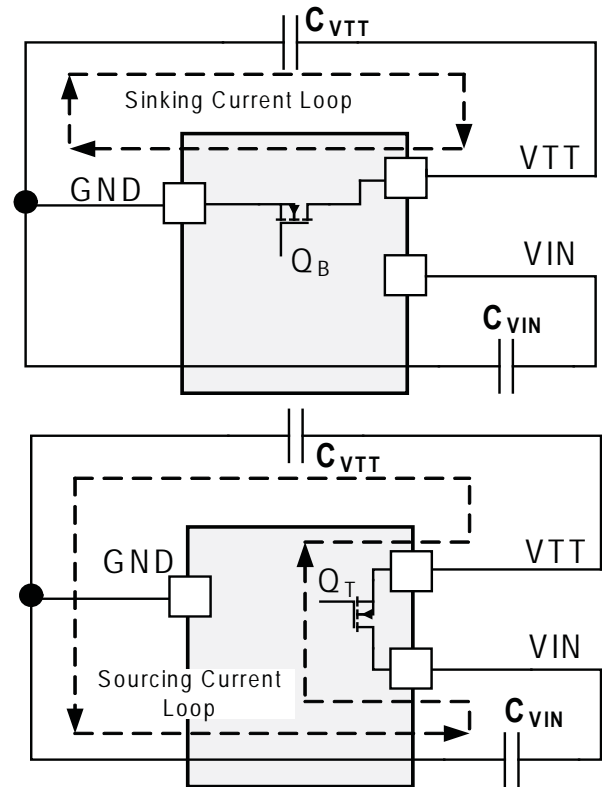
An R-C filter from the supply used for VDDQ consisting of a 100  $\Omega$  resistor and a 0.1 $\mu$ F capacitor should be placed as close as possible to the IC and connected between pin 5 (VDDQ) and the ground plane, as shown on page 6.

VTT and VIN Capacitors:

Since SC2599 provides both sink and source capabilities, the loop impedance through the input and VTT capacitors plays an important role in circuit stability. Figure 4 shows both sink and source current loops. Close attention to board layout is needed to reduce ESL in these loops. During a bode plot measurement for the sourcing current loop, an injected small AC signal flows around the loop from  $C_{VIN}$  to  $Q_T$  through  $C_{VTT}$  and then returns to  $C_{VIN}$  through the ground plane. Therefore, it is recommended to keep the  $C_{IN}$  and  $C_{VTT}$  capacitors as close as possible to reduce

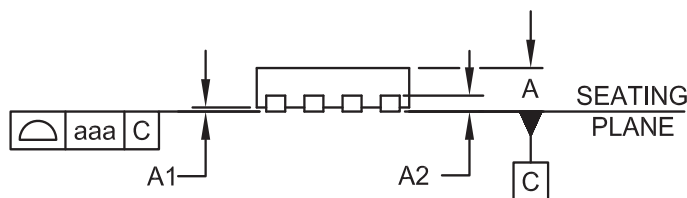
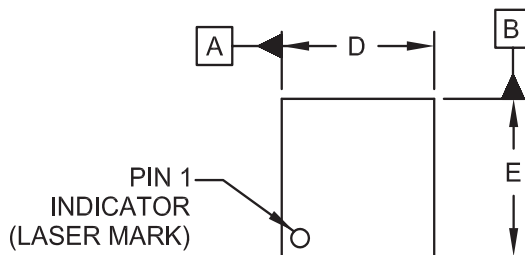


**Figure 3 — Component Placement and Layout**

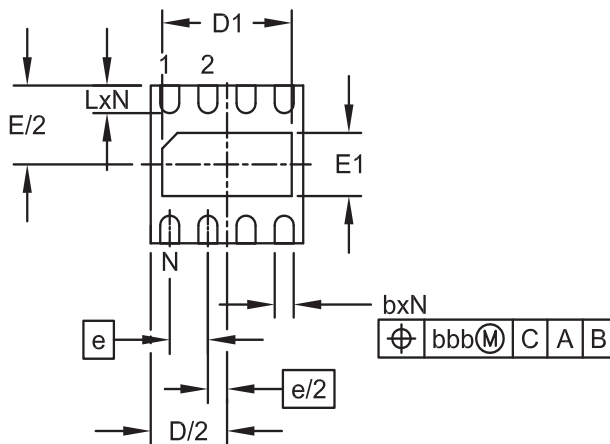


**Figure 4 — Small AC Signal Current Loops**

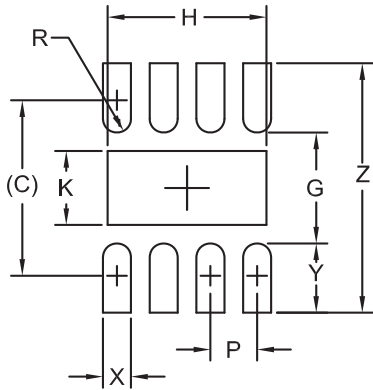
the ESL impedance between them. Similarly in the sinking current loop, an injected small AC signal flows from  $C_{VTT}$  through  $Q_B$  and then returns to  $C_{VTT}$  through the GND plane. Therefore, it is recommended to keep ESL small for this loop. Balancing the ESL of those loops gives the best case for stability.

**Outline Drawing — MLPD8**


DIM	INCHES			MILLIMETERS		
	MIN	NOM	MAX	MIN	NOM	MAX
A	.020	-	.024	0.50	-	0.60
A1	.000	-	.002	0.00	-	0.05
A2	(.006)			(0.1524)		
b	.007	.010	.012	0.18	0.25	0.30
D	.075	.079	.083	1.90	2.00	2.10
D1	.061	.067	.071	1.55	1.70	1.80
E	.075	.079	.083	1.90	2.00	2.10
E1	.026	.031	.035	0.65	0.80	0.90
e	.020 BSC			0.50 BSC		
L	.012	.014	.016	0.30	0.35	0.40
N	8			8		
aaa	.003			0.08		
bbb	.004			0.10		


**NOTES:**

1. CONTROLLING DIMENSIONS ARE IN MILLIMETERS (ANGLES IN DEGREES).
2. COPLANARITY APPLIES TO THE EXPOSED PAD AS WELL AS THE TERMINALS.

**Land Pattern — MLPD8**


DIMENSIONS		
DIM	INCHES	MILLIMETERS
C	(.077)	(1.95)
G	.047	1.20
H	.067	1.70
K	.031	0.80
P	.020	0.50
R	.006	0.15
X	.012	0.30
Y	.030	0.75
Z	.106	2.70

**NOTES:**

1. CONTROLLING DIMENSIONS ARE IN MILLIMETERS (ANGLES IN DEGREES).
2. THIS LAND PATTERN IS FOR REFERENCE PURPOSES ONLY. CONSULT YOUR MANUFACTURING GROUP TO ENSURE YOUR COMPANY'S MANUFACTURING GUIDELINES ARE MET.
3. THERMAL VIAS IN THE LAND PATTERN OF THE EXPOSED PAD SHALL BE CONNECTED TO A SYSTEM GROUND PLANE. FAILURE TO DO SO MAY COMPROMISE THE THERMAL AND/OR FUNCTIONAL PERFORMANCE OF THE DEVICE.

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