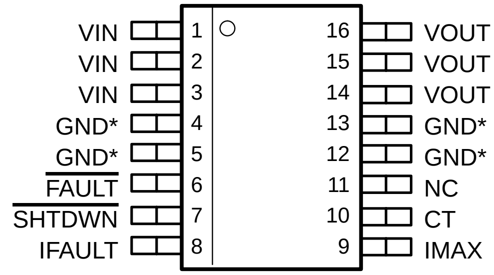
UCC2918/81510
LOW ON-RESISTANCE HOT SWAP POWER MANAGER

SLUS457C – JULY 2000 - REVISED APRIL 2001

- **Integrated 0.075-Ω Power MOSFET**
- **3 V to 6 V Operation**
- **External Analog Control of Fault Current From 0 A to 4 A**
- **Independent Analog Control of Current Limit up to 5 A**
- **Fast Overload Protection**
- **Unidirectional Switch**
- **Minimal External Components**
- **1-µA I_{CC} When Disabled**
- **Programmable On Time**
- **Programmable Start Delay**
- **Fixed 3% Duty Cycle**

DP PACKAGE
(TOP VIEW)

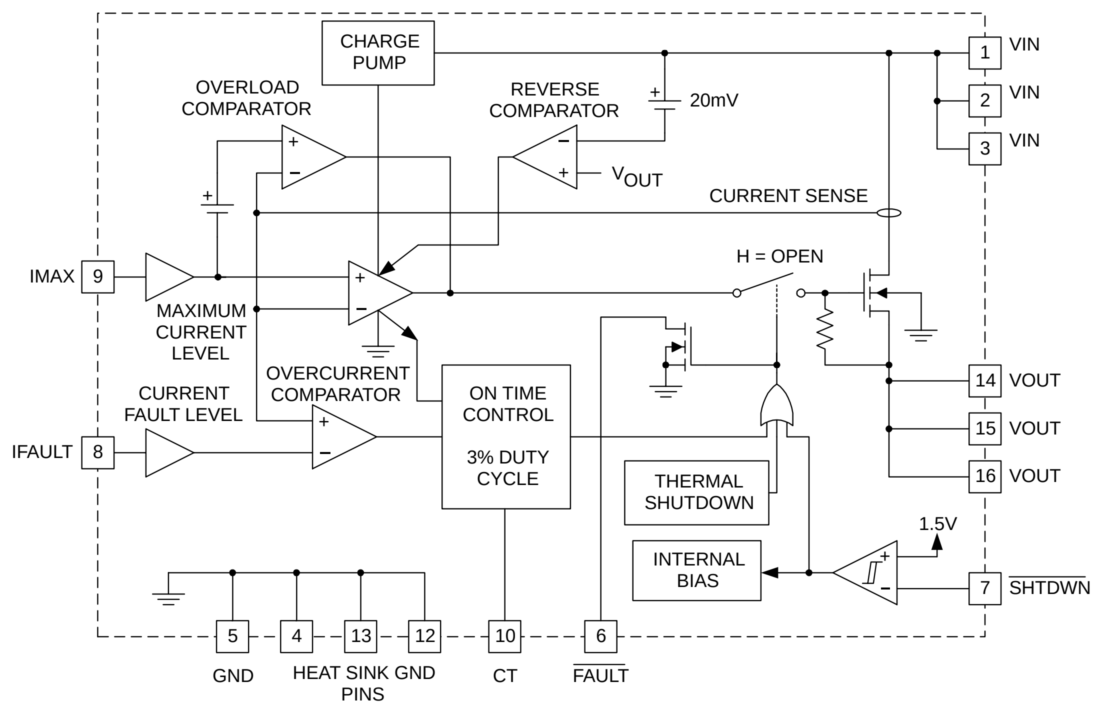


Pin 5 serves as the lowest impedance to the electrical ground. Pins 4, 12, and 13, serve as heat sink/ground. These pins should be connected to large etch PCB areas to help dissipate heat.

description

The UCC2918 low on-resistance hot swap power manager provides complete power management, hot swap capability, and circuit breaker functions. The only components needed to operate the device, other than supply bypassing, are a timing capacitor and two programming resistors. All control and housekeeping functions are integrated and externally programmable. These include the fault current level, maximum output sourcing current, maximum fault time, and startup delay. In the event of a constant fault, the internal fixed 3% duty cycle ratio limits the average output power. The IFAULT pin allows linear programming of the fault level current from 0 A to 4 A.

functional block diagram



UDG–00101

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description (continued)

Fast overload protection is accomplished by an additional overload comparator. Its threshold is internally set above the maximum sourcing current limit setting. In the event of a short circuit or extreme current condition, this comparator is tripped, shutting down the output. This function is needed since the maximum sourcing current limit loop has a finite bandwidth.

When the output current is below the fault level, the output MOSFET is switched on with a nominal resistance of 0.075 Ω. When the output current exceeds the fault level or the maximum sourcing level, the output remains on, but the fault timer starts charging a capacitor connected to the CT pin (C_T). Once C_T charges to a preset threshold, the switch is turned off, and remains off for 30 times the programmed fault time. When the output current reaches the maximum sourcing level, the MOSFET transitions from a switch to a constant current source.

The UCC2918 is designed for unidirectional current flow, emulating an ideal diode in series with the power switch. This feature is particularly attractive in applications where many devices are powering a common bus, such as with SCSI termintation power (Termpwr). The UCC2918 can also be put into the sleep mode, drawing only 1 µA of supply current.

Other features include an open-drain fault output indicator, thermal shutdown, undervoltage lockout, 3 V to 6 V operation, and a low thermal resistance small-outline power package.

absolute maximum ratings over operating free-air temperature (unless otherwise noted)†‡

Input voltage	8 V
SOIC power dissipation	2.5 W
Fault output sink current	50 mA
Fault output voltage	VIN
Output current (dc)	Internally Limited
Input voltage $\overline{\text{SHTDWN}}$, IFAULT, IMAX	–0.3 V to VIN
Storage temperature range, T_{stg}	–65°C to 150°C
Operating virtual junction temperature, T_J	–55°C to 150°C
Lead temperature (soldering, 10 seconds)	300°C

† Stresses beyond those listed under “absolute maximum ratings” may cause permanent damage to the device. These are stress ratings only, and functional operation of the device at these or any other conditions beyond those indicated under “recommended operating conditions” is not implied. Exposure to absolute-maximum-rated conditions for extended periods may affect device reliability.

‡ Unless otherwise indicated, voltages are reference to ground and currents are positive into, negative out of the specified terminal. Pulsed is defined as a less than 10% duty cycle with a maximum duration of 500 µs. Consult *Packaging Section* of Databook for thermal limitations and considerations of package.

electrical characteristics at T_A = –40°C to 85°C, VIN = 5 V, R_{IMAX} = 42.2 kΩ, R_{IFAULT} = 52.3 kΩ, SHTDWN = 2.4 V, C_T = 0.1 µF, T_A = T_J (unless otherwise noted)

PARAMETER	TEST CONDITIONS	MIN	TYP	MAX	UNITS
Supply Section					
Voltage input range, VIN		3	5	6	V
VDD supply current	No load		1	2	mA
Sleep mode current	$\overline{SHTDWN}$ = 0.2 V		0.5	5	µA
Output Section					
$R_{DS(on)}$	I_{OUT} = 1 A to 4 A, VIN = 5 V, T_A = 25°C		0.075	0.095	Ω
	I_{OUT} = 1 A to 4 A, VIN = 3 V, T_A = 25°C		0.09	0.116	Ω
	I_{OUT} = 1 A to 4 A, VIN = 5 V		0.075	0.125	Ω
	I_{OUT} = 1 A to 4 A, VIN = 3 V		0.09	0.154	Ω
Reverse leakage current	$\overline{SHTDWN}$ = 0 V, VIN = 0 V V_{OUT} = 5 V			20	µA
Initial start-up time	See Note 1		100		µs
Thermal shutdown	See Note 1		170		°C
Thermal hysteresis	See Note 1		10		°C
Output leakage	$\overline{SHTDWN}$ = 0.2 V			20	µA
Trip current	R_{IFAULT} = 105 kΩ	0.75	1	1.25	A
	R_{IFAULT} = 52.3 kΩ	1.7	2	2.3	A
	R_{IFAULT} = 34.8 kΩ	2.5	3	3.5	A
	R_{IFAULT} = 25.5 kΩ	3.3	4	4.7	A
Maximum output current	R_{IMAX} = 118 kΩ	0.3	1	1.7	A
	R_{IMAX} = 60.4 kΩ	1	2	3	A
	R_{IMAX} = 42.2 kΩ	2	3	4	A
	R_{IMAX} = 33.2 kΩ	2.5	3.8	5.1	A
	R_{IMAX} = 27.4 kΩ	3.0	4.6	6.2	A
Fault Section					
C_T charge current	V_{CT} = 1 V	–50	–36	–22	µA
C_T discharge current	V_{CT} = 1 V	0.5	1.2	2.0	µA
Output duty cycle	VOUT = 0 V	1.5	3	6	%
C_T fault threshold		0.8	1.3	1.8	V
C_T reset threshold		0.25	0.5	0.75	V
Shutdown Section					
Shutdown threshold		1.1	1.5	2.0	V
Shutdown hysteresis			100		mV
Input low current	$\overline{SHTDWN}$ = 0 V	–500	0	500	nA
Input high current	$\overline{SHTDWN}$ = 2 V	–2	–1	–0.5	µA
Open Drain Fault Output Section					
High level output current				1	µA
Low level output voltage	I_{OUT} = 1 mA		0.4	0.9	V

NOTE 1: Ensured by design. Not production tested.

pin descriptions

CT: A capacitor connected to this pin sets the maximum fault time. The maximum time must be greater than the time to charge external load capacitance. The nominal fault time is defined as:

$$T_{FAULT} = 22.2 \times 10^{3} \times C_{T} \tag{1}$$

Once the fault time is reached, the output shuts down for a time given by:

$$T_{SD} = 0.667 \times 10^{6} \times C_{T} \tag{2}$$

This equates to a 3% duty cycle. The recommended minimum value for the C_T capacitor is 0.1 µF.

$\overline{\text{FAULT}}$: Open-drain output, which pulls low on any condition that causes the output to open; fault, thermal shutdown, shutdown, and maximum sourcing current greater than the fault time.

GND: This is the most negative voltage in the circuit. All 4 ground pins should be used, and properly heat sunk on the PCB.

IFAULT: A resistor connected from this pin to ground sets the fault threshold. The resistor versus fault current is set by the formula:

$$R_{FAULT} = \frac{105\ k\Omega}{I_{TRIP}} \tag{3}$$

IMAX: A resistor connected from this pin to ground sets the maximum sourcing current. The resistor vs the output sourcing current is set by the formula:

$$R_{IMAX} = \frac{126\ k\Omega}{\text{Maximum Sourcing Current}} \tag{4}$$

$\overline{\text{SHTDWN}}$: When this pin is brought low, the IC is put into sleep mode. The input threshold is hysteretic, allowing the user to program a startup delay with an external RC circuit.

VIN: This is the input voltage to the UCC2918. The recommended operating voltage range is 3V to 6V. All VIN pins should be connected together and to the power source.

VOUT: Output voltage for the circuit breaker. When switched the output voltage will be approximately:

$$V_{OUT} = V_{IN} - 0.075\ \Omega \times I_{OUT}\ . \tag{5}$$

All VOUT pins should be connected together and to the load.

APPLICATION INFORMATION

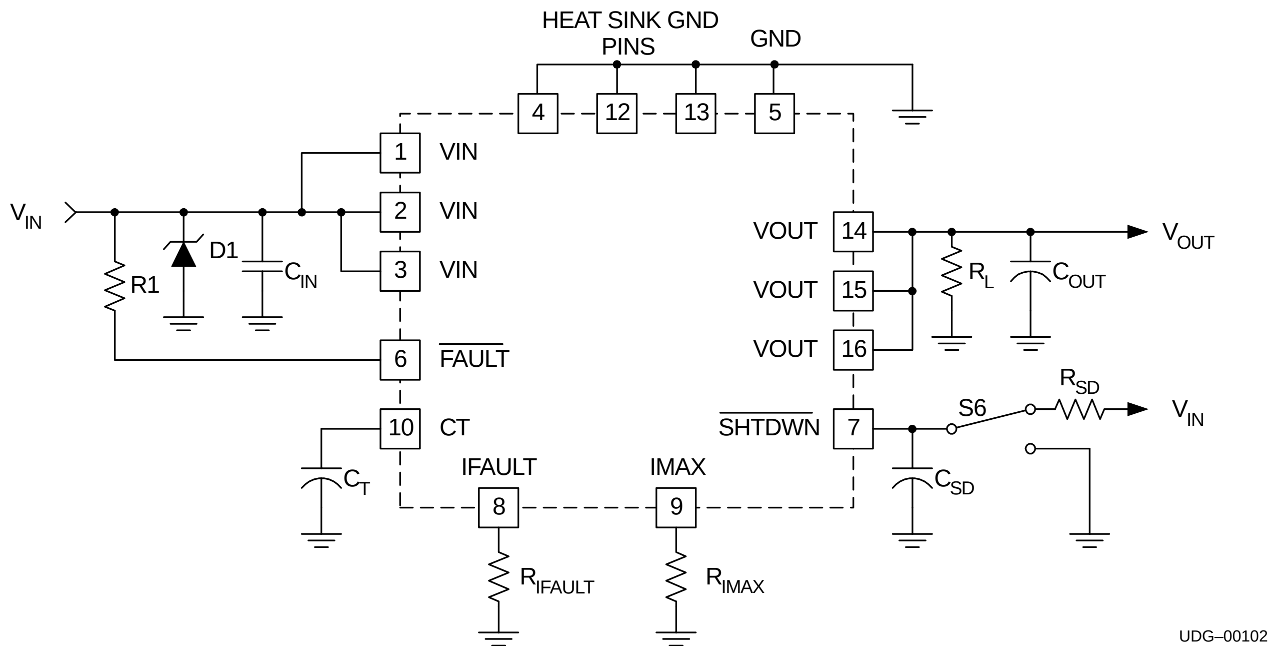

Figure 1. Typical Application

protecting the UCC2918 from voltage transients

The parasitic inductance associated with the power distribution can cause a voltage spike at V_{IN} if the load current is suddenly interrupted by the UCC2918. *It is important to limit the peak of this spike to less than 6 V to prevent damage to the UCC2918*. This voltage spike can be minimized by:

- Reducing the power distribution inductance (e.g., twist the positive + and negative – leads of the power supply feeding V_{IN}, locate the power supply close to the UCC2918 or use a PCB ground plane).
- Decoupling V_{IN} with a capacitor, C_{IN} (refer to Figure 1), located close to the VIN pin. This capacitor is typically less than 1 µF to limit the inrush current.
- Clamping the voltage at V_{IN} below 6 V with a Zener diode, D1 (refer to Figure 1), located close to the VIN pin.

estimating maximum load capacitance

For circuit breaker applications, the rate at which the total output capacitance can be charged depends on the maximum output current available and the nature of the load. For a constant-current current-limited circuit breaker, the output comes up if the load requires less than the maximum available short-circuit current.

To ensure recovery of a duty-cycle of the current-limited circuit breaker from a short-circuited load condition, there is a maximum total output capacitance that can be charged for a given unit ON time (fault time). The design value of ON or fault time can be adjusted by changing the timing capacitor C_T.

APPLICATION INFORMATION

estimating maximum load capacitance

For worst-case constant-current load of value just less than the trip limit, $C_{OUT(max)}$ can be estimated from:

$$C_{OUT(max)} \approx \left(I_{MAX} - I_{LOAD}\right)\left(\frac{22 \times 10^3 \times C_T}{V_{OUT}}\right) \tag{6}$$

Where V_{OUT} is the output voltage and I_{MAX} is the maximum sourcing current.

For a resistive load of value R_{LOAD}, the value of $C_{OUT(max)}$ can be estimated from:

$$C_{OUT(max)} \approx \left[\frac{22 \times 10^3 \times C_T}{R_{LOAD} \times \ell n\left[\frac{1}{1 - \frac{V_{OUT}}{I_{MAX} \times R_{LOAD}}}\right]}\right] \tag{7}$$

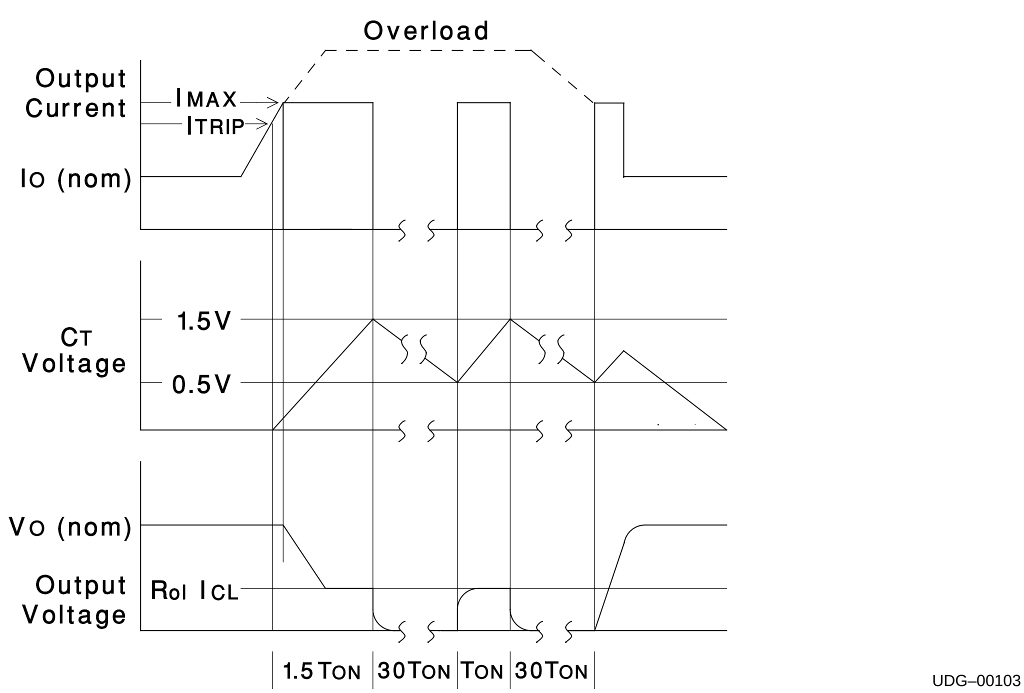

Figure 2. Load Curent, Timing Capacitor Voltage, and Output Voltage of the UCC2918 Under Fault

TYPICAL CHARACTERISTICS

REVERSE VOLTAGE COMPARATOR RESPONSE TIME

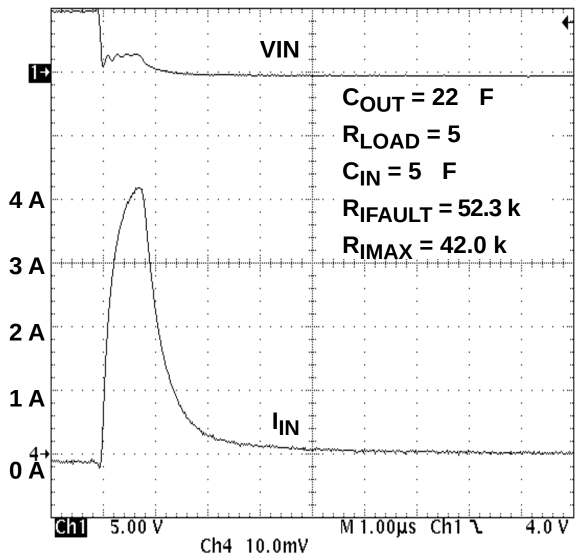

Figure 3

FAULT TIMING WAVEFORMS

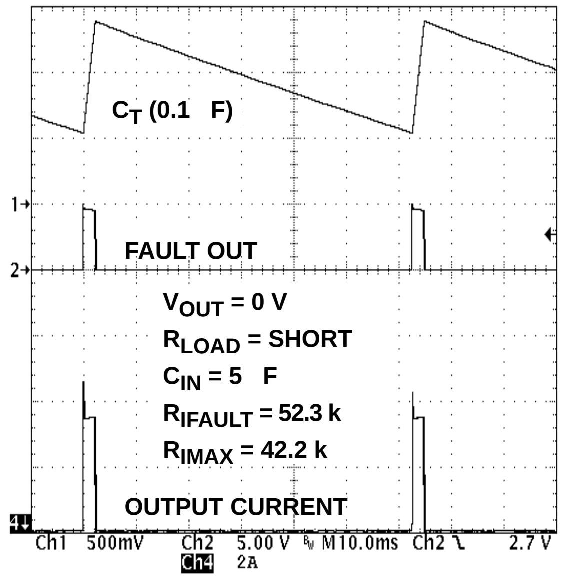

Figure 4

NOTE: In Figure 3 the input driven with a pulse generator shows C_{OUT} discharging through R_L and conducting through UCC81510 FET in the reverse direction.

INRUSH CURRENT LIMITING

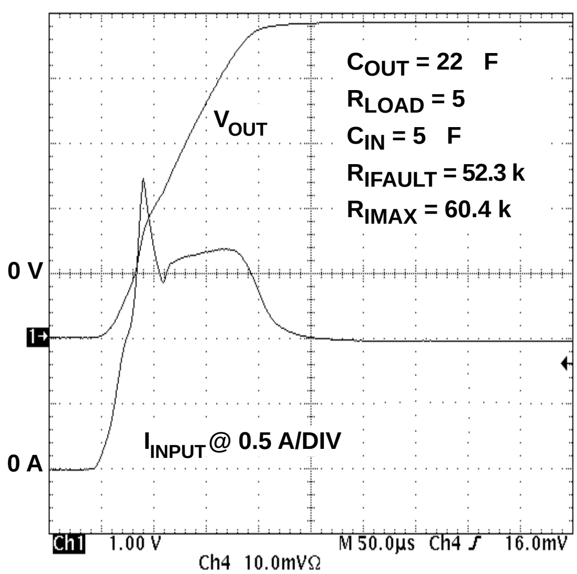

Figure 5

$\overline{\text{FAULT}}$ AND OUTPUT TURN-OFF DELAY FROM CT FAULT THRESHOLD

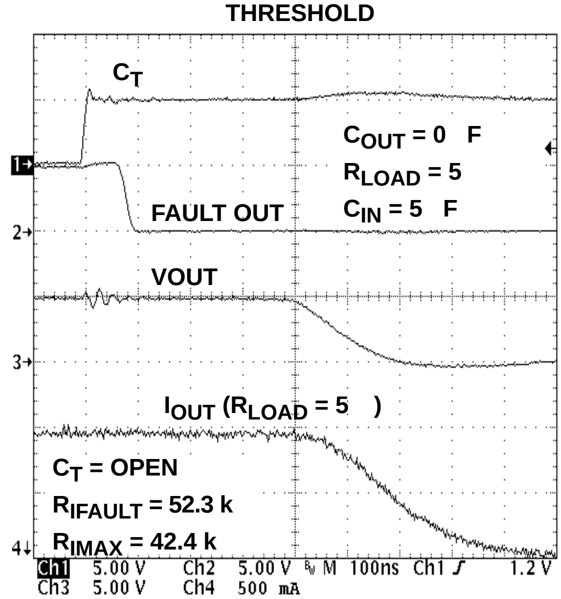

Figure 6

NOTE: In Figure 5 the input is switched on through the external FET. V_{OUT} shows I_{MAX} linear amplifier limiting the changing current to C_{OUT}.

TYPICAL CHARACTERISTICS

PROPAGATION DELAY SHUTDOWN TO FAULT AND OUTPUT RAMP-DOWN

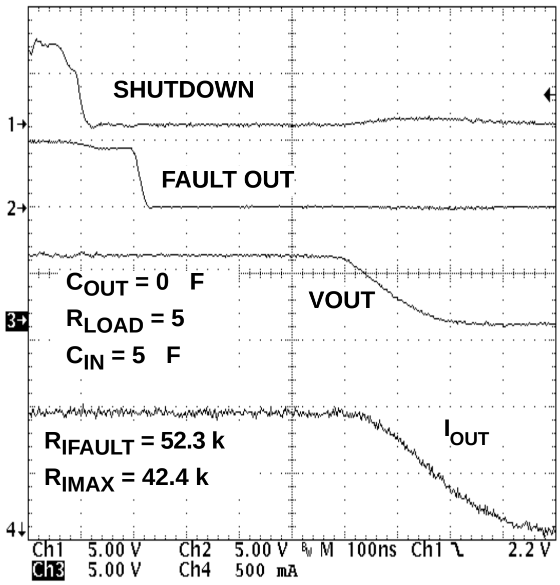

Figure 7

PROPAGATION DELAY ENABLE TO FAULT AND OUTPUT RAMP-UP

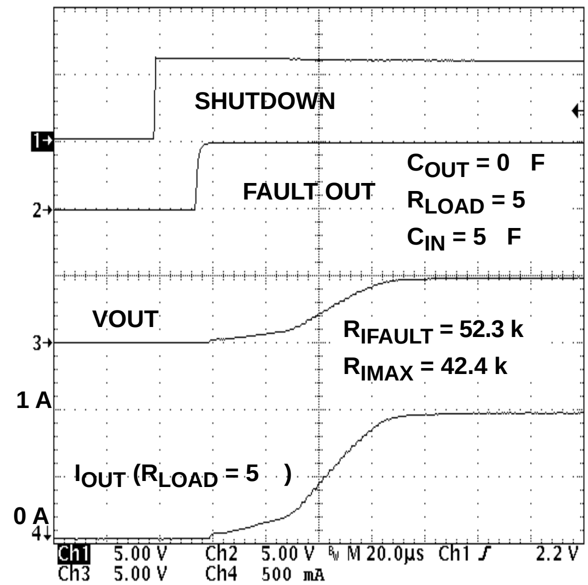

Figure 8

ON-STATE RESISTANCE vs OUTPUT CURRENT

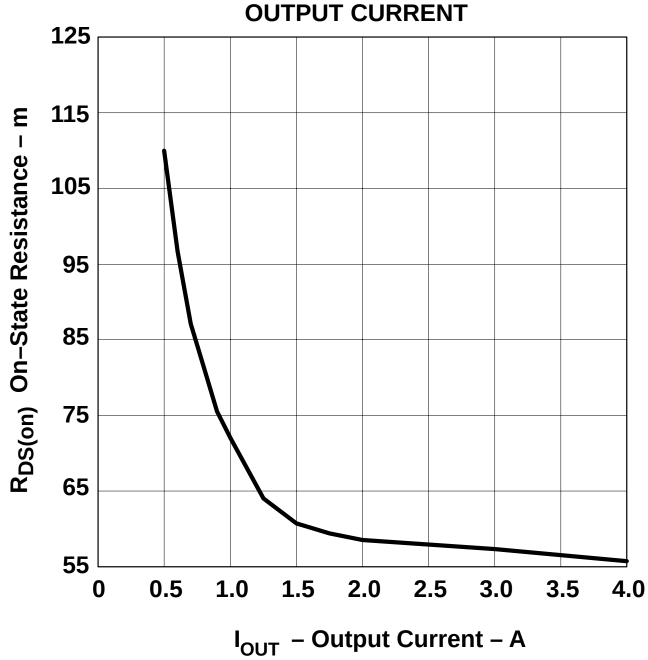

Figure 9

ON-STATE RESISTANCE vs TEMPERATURE

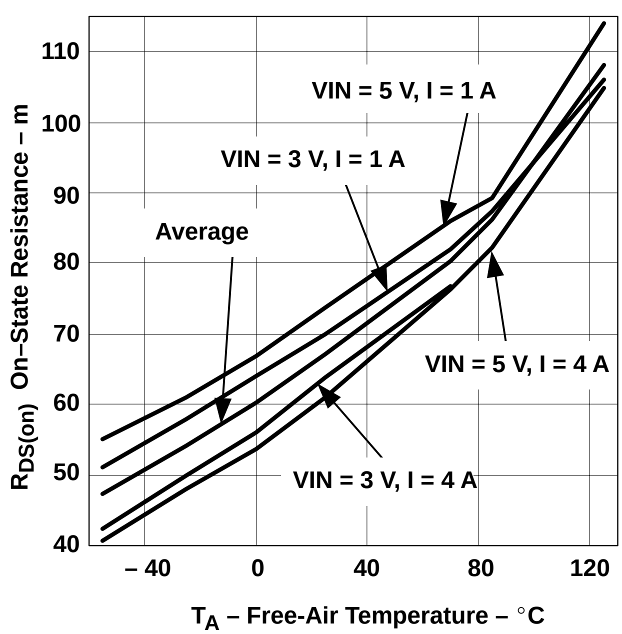

Figure 10

APPLICATION INFORMATION

safety considerations

Although the UCC2918 is designed to provide system protection for all fault conditions, all integrated circuits can ultimately fall short. For this reason, if the UCC2918 is intended for use in safety critical applications where UL© or some other safety rating is required, a redundant safety device such as a fuse should be placed in series with the power device. The UCC2918 prevents the fuse from blowing for virtually all fault conditions, increasing system reliability and reducing maintenance cost, in addition to providing the hot swap benefits of the device.

PACKAGING INFORMATION

Orderable Device	Status [1]	Package Type	Package Drawing	Pins	Package Qty	Eco Plan [2]	Lead/Ball Finish	MSL Peak Temp [3]
UCC2918DP	OBSOLETE	SOIC	D	16		TBD	Call TI	Call TI
UCC2918DPTR	OBSOLETE	SOIC	D	16		TBD	Call TI	Call TI
UCC2918J	OBSOLETE		UTR	16		TBD	Call TI	Call TI
UCC2918N	OBSOLETE	PDIP	N	16		TBD	Call TI	Call TI
UCC2918PWP	OBSOLETE	TSSOP	PW	24		TBD	Call TI	Call TI
UCC2918PWPTR	OBSOLETE	TSSOP	PW	24		TBD	Call TI	Call TI
UCC2918QP	OBSOLETE		UTR	28		TBD	Call TI	Call TI

[1] The marketing status values are defined as follows:
ACTIVE: Product device recommended for new designs.
LIFEBUY: TI has announced that the device will be discontinued, and a lifetime-buy period is in effect.
NRND: Not recommended for new designs. Device is in production to support existing customers, but TI does not recommend using this part in a new design.
PREVIEW: Device has been announced but is not in production. Samples may or may not be available.
OBSOLETE: TI has discontinued the production of the device.

[2] Eco Plan - The planned eco-friendly classification: Pb-Free (RoHS) or Green (RoHS & no Sb/Br) - please check http://www.ti.com/productcontent for the latest availability information and additional product content details.
TBD: The Pb-Free/Green conversion plan has not been defined.
Pb-Free (RoHS): TI's terms "Lead-Free" or "Pb-Free" mean semiconductor products that are compatible with the current RoHS requirements for all 6 substances, including the requirement that lead not exceed 0.1% by weight in homogeneous materials. Where designed to be soldered at high temperatures, TI Pb-Free products are suitable for use in specified lead-free processes.
Green (RoHS & no Sb/Br): TI defines "Green" to mean Pb-Free (RoHS compatible), and free of Bromine (Br) and Antimony (Sb) based flame retardants (Br or Sb do not exceed 0.1% by weight in homogeneous material)

[3] MSL, Peak Temp. -- The Moisture Sensitivity Level rating according to the JEDEC industry standard classifications, and peak solder temperature.

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