

# NCP81295, NCP81296

## Hot Swap Smart Fuse

The NCP81295 and NCP81296 are 50 A, electronically re-settable, in-line fuses for use in 12 V, high current applications such as servers, storage and base stations. The NCP81295/6 offers a very low 0.65 m $\Omega$  integrated MOSFET to reduce solution size and minimize power loss. It also integrates a highly accurate current sensor for monitoring and overload protection.

### Power Features

- Co-packaged Power Switch, Hotswap Controller and Current Sense
- Up to 60 A Peak Current Output, 50 A Continuous
- Vin Range: 4.5 V to 18 V
- 0.65 m $\Omega$ , no R<sub>SENSE</sub> Required

### Control Features

- Enable Input
- Optional Enable-controlled Output Pulldown when Disabled
- Programmable Soft-Start
- Programmable, Multi-level Current Limit

### Reporting Features

- Accurate Analog Load Current Monitor
- Programmable Over Current Alert Output
- Analog Temperature Output
- Status Fault OK Output

### Other Features

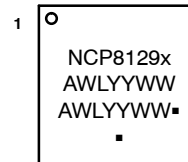
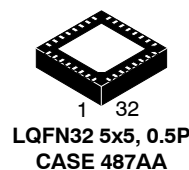
- 5 mm x 5 mm QFN32 Package
- Operating Temperature: -40°C to 125°C
- Can be Paralleled for Higher Current Applications
- Built-in Insertion Delay for Hotswap Applications
- NCP81295: Latch off for Following Protection Features
- NCP81296: Auto-Retry Mode for Following Protection Features
  - ◆ Current-limit after Delay
  - ◆ Fast Short-circuit Protection
  - ◆ Over-Temperature Shutdown
  - ◆ Excessive Soft-start Duration
- Internal Switch Fault Diagnostics
- Low-power Auxiliary Output Voltage



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### MARKING DIAGRAM



NCP8129x = Specific Device Code

x = 5 or 6

A = Assembly Location

WL = Wafer Lot

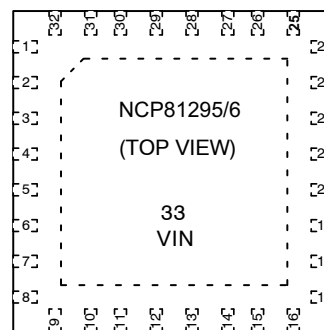
YY = Year

WW = Work Week

▪ = Pb-Free Package  
(may or may not be present)

(Note: Microdot may be in either location)

### PINOUT



For more details see Figure 1.

### ORDERING INFORMATION

See detailed ordering and shipping information on page 2 of this data sheet.

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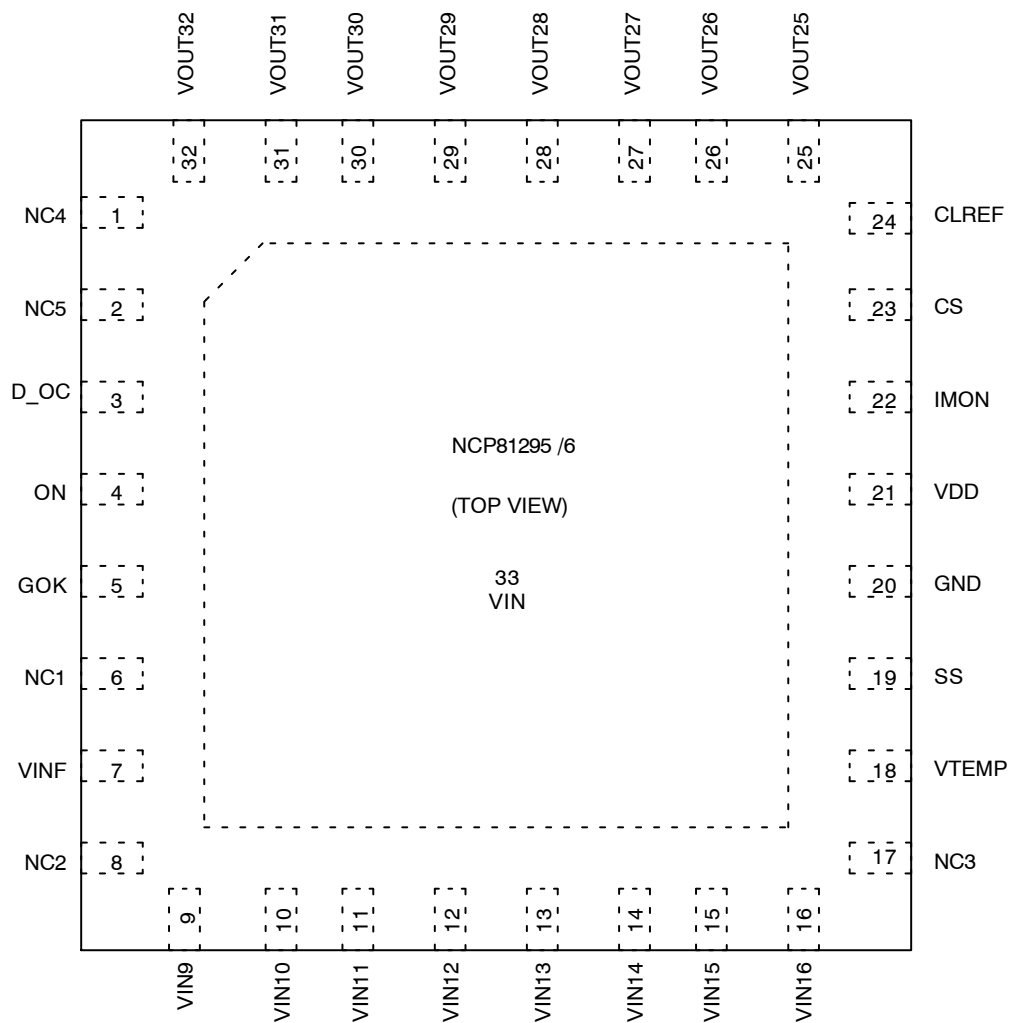


Figure 1. Pin Configuration

### Ordering Information

Table 1. AVAILABLE DEVICES

Device	Package	Shipping <sup>†</sup>
NCP81295MNTXG	QFN32	2500/Tape & Reel
NCP81296MNTXG	QFN32	2500/Tape & Reel

<sup>†</sup>For information on tape and reel specifications, including part orientation and tape sizes, please refer to our Tape and Reel Packaging Specifications Brochure, BRD8011/D.

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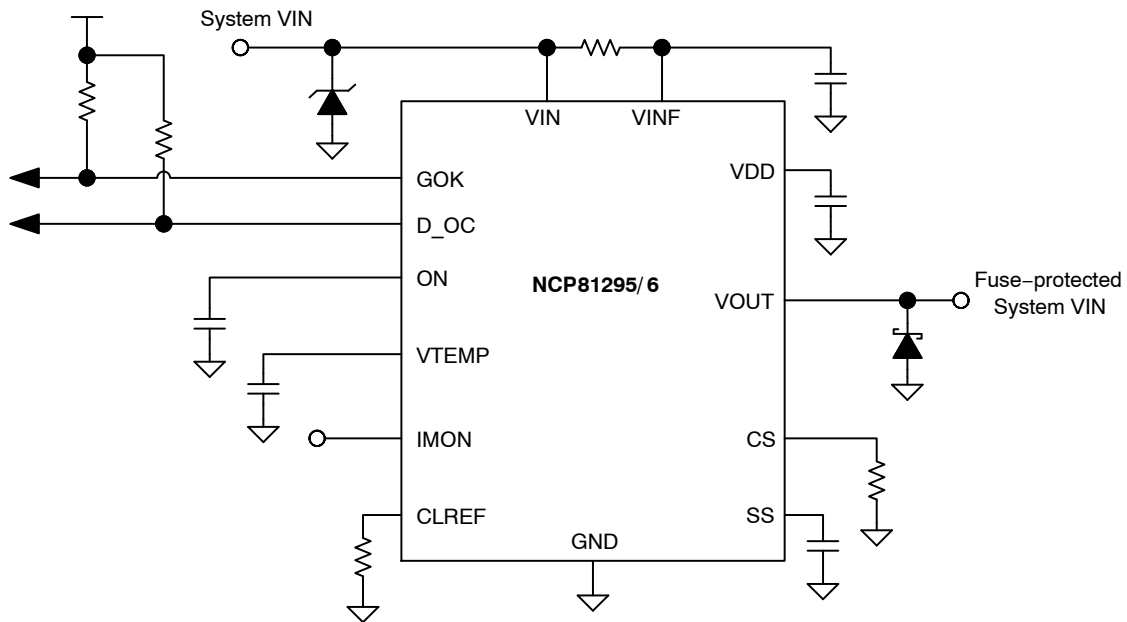


Figure 2. Typical Application

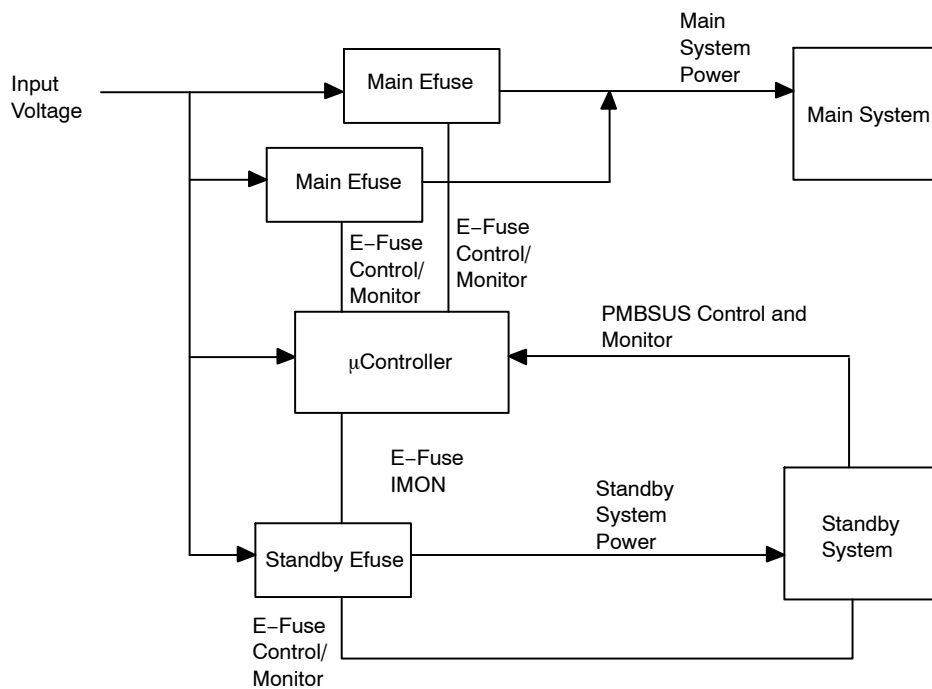


Figure 3. Typical Application Diagram

# NCP81295, NCP81296

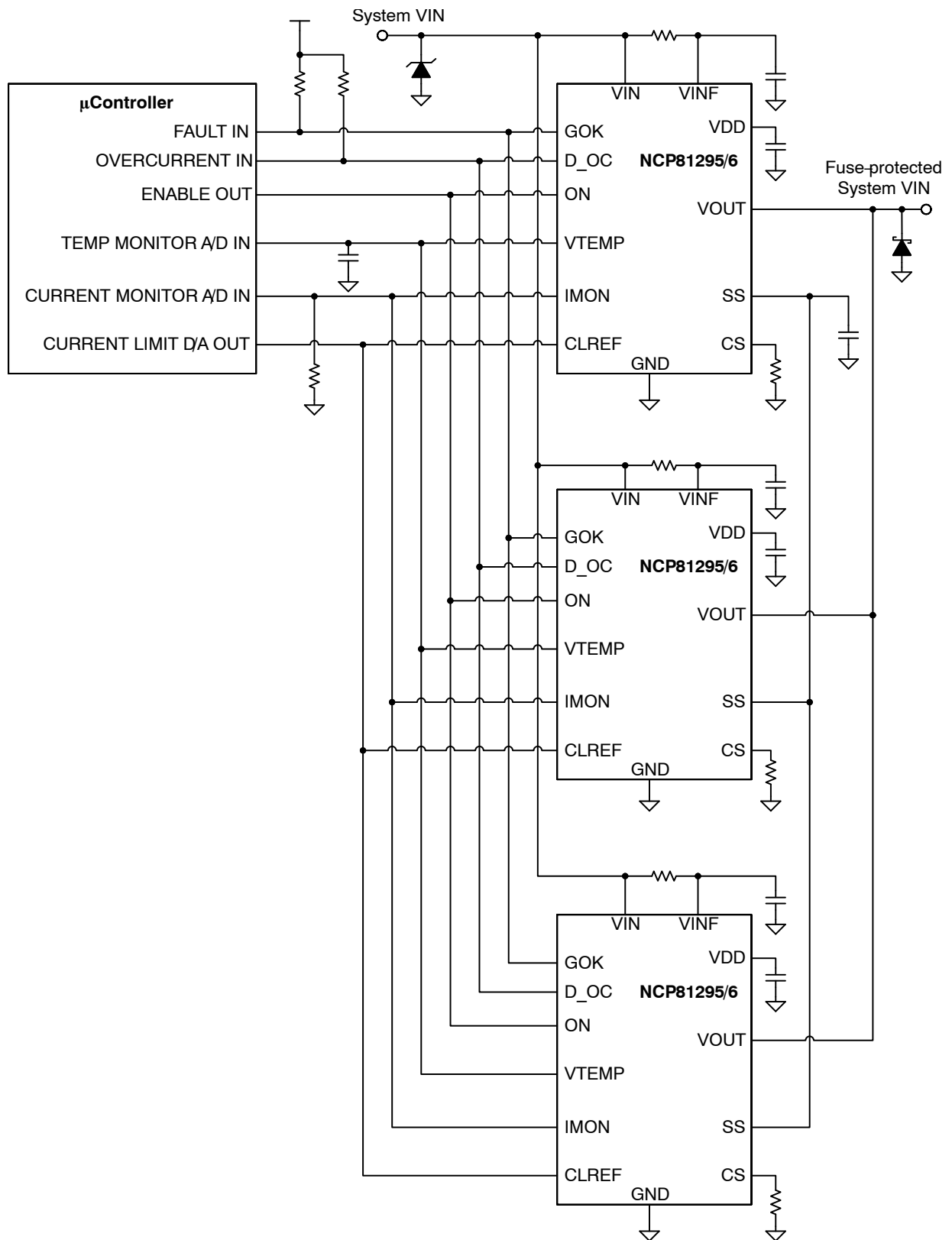


Figure 4. Application Schematic – Parallel Fuse Operation with Controller

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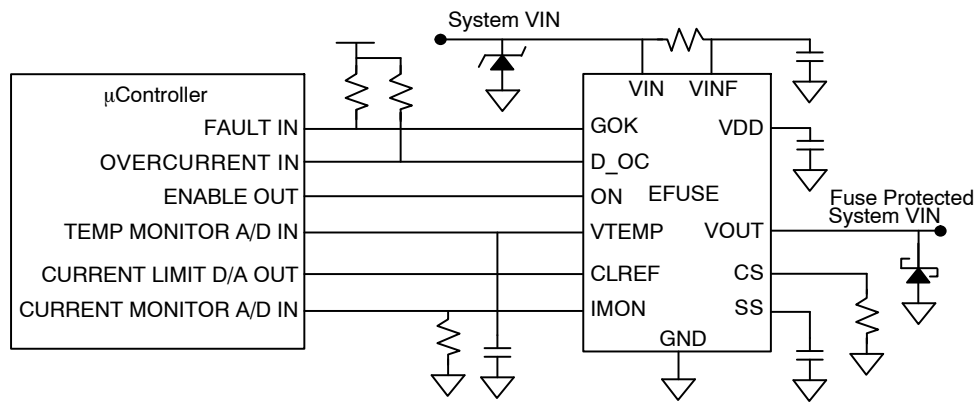


Figure 5. Application Schematic – Single EFuse with Controller

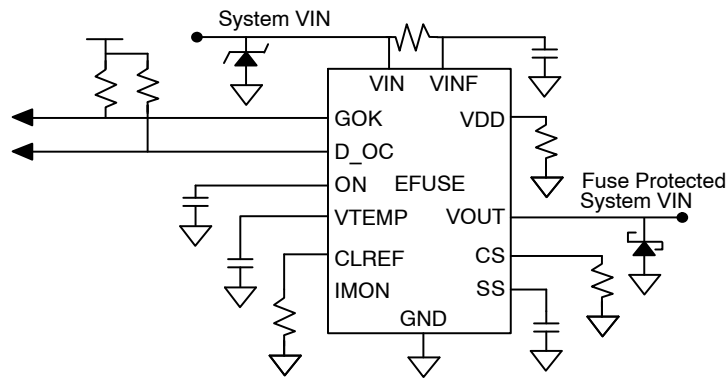


Figure 6. Application Schematic – Stand-alone Operation

# NCP81295, NCP81296

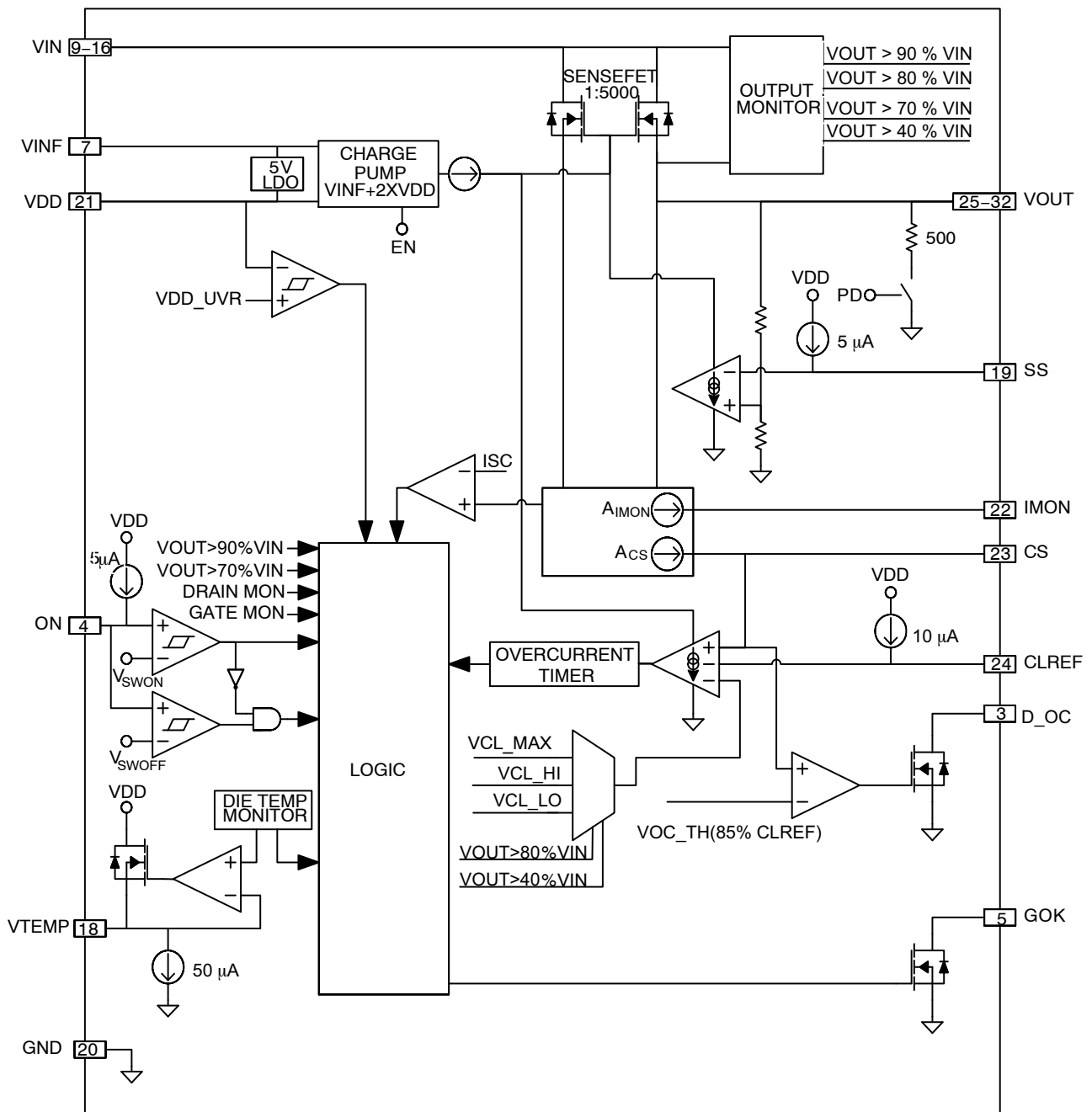


Figure 7. Block Diagram

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**Table 2. PIN DESCRIPTION**

Pin No.	Symbol	Description
1	NC4	No electrical connection internally. May connect to any potential
2	NC5	No electrical connection internally. May connect to any potential
3	D_OC	Overcurrent indicator output (open drain). Low indicates the NCP81295 is limiting current. The D_OC output does not report current limiting during soft-start.
4	ON	Enable input and output pulldown resistance control.
5	GOK	OK status indicator output (open drain). Low indicates that the NCP81295 was turned off by a fault.
6	NC1	Test pin. Do not connect to this pin. Leave floating
7	VINF	Control circuit power supply input. Connect to VIN pins through an RC filter.
8	NC2	Internal FET sense pin. Do not connect to this pin. Leave floating
9	VIN09	Input of high current output switch
10	VIN10	Input of high current output switch
11	VIN11	Input of high current output switch
12	VIN12	Input of high current output switch
13	VIN13	Input of high current output switch
14	VIN14	Input of high current output switch
15	VIN15	Input of high current output switch
16	VIN16	Input of high current output switch
17	NC3	Internal FET gate pin. Do not connect to this pin. Leave floating
18	VTEMP	Analog temperature monitor output.
19	SS	Soft Start time programming pin. Connect a capacitor to this pin to set the softstart time.
20	GND	Ground
21	VDD	Linear regulator output
22	IMON	Analog current monitor output
23	CS	Current sense feedback output (current). Scaling the voltage developed at this pin with a resistor to ground makes this also an input for several current limiting functions and overcurrent indicator D_OC.
24	CLREF	Current limit setpoint input for normal operation (after soft-start).
25	VOUT25	Output of high current output switch
26	VOUT26	Output of high current output switch
27	VOUT27	Output of high current output switch
28	VOUT28	Output of high current output switch
29	VOUT29	Output of high current output switch
30	VOUT30	Output of high current output switch
31	VOUT31	Output of high current output switch
32	VOUT32	Output of high current output switch
33	VIN33	Input of high current output switch

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**Table 3. MAXIMUM RATINGS**

Rating	Symbol	Min	Max	Unit
Pin Voltage Range (Note 2)	VINx, VINf	-0.3	20	V
Pin Voltage Range (Note 2)	VOUTx	-0.3 -1(<500 ms)	20	V
Pin Voltage Range (Note 2)	VDD	-0.3	6.0	V
Pin Voltage Range (Note 2)	All Other Pins	-0.3	VDD + 0.3	V
Operating Junction Temperature	T <sub>J(max)</sub>		150	°C
Storage Temperature Range	TSTG	-55	150	°C
Lead Temperature Soldering Reflow (SMD Styles Only), Pb-Free Versions (Note 3)	T <sub>SLD</sub>		260	°C

Stresses exceeding those listed in the Maximum Ratings table may damage the device. If any of these limits are exceeded, device functionality should not be assumed, damage may occur and reliability may be affected.

1. All signals referenced to GND unless noted otherwise.
2. Pin ratings referenced to VDD apply with VDD at any voltage within the VDD Pin Voltage Range.
3. For information, please refer to our Soldering and Mounting Techniques Reference Manual, SOLDERRM/D

**Table 4. THERMAL CHARACTERISTICS**

Rating	Symbol	Value	Unit
Thermal Resistance, Junction-to-Ambient (Note 4)	R <sub>θJA</sub>	30	°C/W
Thermal Resistance, Junction-to-Top-Case	R <sub>θJCT</sub>	50	°C/W
Thermal Resistance, Junction-to-Bottom-Case	R <sub>θJCB</sub>	1.5	°C/W
Thermal Resistance, Junction-to-Board (Note 5)	R <sub>θJB</sub>	1.5	°C/W
Thermal Resistance, Junction-to-Case (Note 6)	R <sub>θJC</sub>	1.5	°C/W

4. Obtained by simulating the device mounted on a 500 mm<sup>2</sup>, 1-oz Cu pad on a 80 mm x 80 mm, 1.6 mm thick 8-layer FR4 board.
5. R<sub>θJB</sub> value based on hottest board temperature within 1 mm of the package.
6. R<sub>θJC</sub> ≈ R<sub>θJCT</sub> // R<sub>θJCB</sub> (Two-Resistor Compact Thermal Model, JESD15-3).

**Table 5. RECOMMENDED OPERATING RANGES**

Parameter	Symbol	Min	Max	Unit
VIN, VINf Pin Voltage Range		4.5	18	V
Maximum Continuous Output Current	I <sub>AVE</sub>		50	A
Peak Output Current	I <sub>PEAK</sub>		60	A
VDD Output Load Capacitance Range	C <sub>VDD</sub>	2.2	10	μF
VTEMP Output Load Capacitance Range	C <sub>VTEMP</sub>	0.1		μF
Softstart Duration	T <sub>SS</sub>	10	100	ms
CS Load Resistance Range	R <sub>CS</sub>	1.8	4	kΩ
CLREF Voltage Range	V <sub>CLREF</sub>	0.2	1.4	V
Operating Junction Temperature	T <sub>J(OP)</sub>	-40	125	°C

Functional operation above the stresses listed in the Recommended Operating Ranges is not implied. Extended exposure to stresses beyond the Recommended Operating Ranges limits may affect device reliability.



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**Table 6. ELECTRICAL CHARACTERISTICS** (VINx = VIN = 12.0 V, VON = 3.3 V, CVINF = 0.1  $\mu$ F, CVDD = 4.7  $\mu$ F, CVTEMP = 0.1  $\mu$ F, RVTEMP = 1 k $\Omega$ , CSS = 100 nF (unless specified otherwise) Min/Max values are valid for the temperature range  $-40^{\circ}\text{C} \leq T_A = T_J \leq 125^{\circ}\text{C}$  unless noted otherwise, and are guaranteed by design and characterization through statistical correlation.

Parameter	Symbol	Test Conditions	Min	Typ	Max	Units
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## VINF INPUT

Quiescent Current		VON > 1.4 V, no load		3.23	5.0	mA
		VON > 1.4 V, fault			5.0	mA
		VON < 0.8 V		2.38	4.0	mA
		VON < 0.8 V, VIN = 16 V			4.0	mA

## VDD REGULATOR

VDD Output Voltage	VDD_NL	IVDD = 0 mA, VIN = 6 V	4.7	5.09	5.3	V
VDD Load Capability	IDDL	VIN = 5.5 V			30	mA
VDD Current Limit	IDDL_CL	VIN = 12 V and VIN = 6 V	50	70		mA
VDD Dropout Voltage		IVDD = 25 mA, VIN = 4.5 V		85	200	mV
UVLO threshold – rising	VDD_UVR		4.1	4.3	4.5	V
UVLO threshold – falling	VDD_UVF		3.8	4.0	4.2	V

## ON INPUT

Bias Current	ION	From pin into a 0 V or 1.5 V source	4.0	5.0	6.0	$\mu$ A
Switch ON Threshold	VSWON		1.3	1.4	1.5	V
Switch OFF/ Pulldown Upper Threshold	VSWOFF			1.2		V
Pulldown Lower Threshold	VPOFF			0.8		V
Switch ON Delay Timer	tON	From ON transitioning above VSWON to SS start	0.6	1.0	2.5	ms
Switch OFF Delay Time (Note 7)	tOFF	From ON transitioning below VSWOFF to GATE pulldown		1.7		$\mu$ s
ON Current Source Clamp Voltage	VON_CLMP	Max pullup voltage of current source		3.0		V
Load Pulldown Delay Timer	tPD_DEL	From ON transitioning into the range between VSWOFF and VPOFF		2.0		ms
Output Pulldown Resistance	RPD	VOUT = 12 V, PD mode = 1		0.77		k $\Omega$

## SS PIN

Bias Current	ISS	From pin into a 0 V or 1 V source	4.62	5.15	5.62	$\mu$ A
Gain to VOUT	AVSS		9.6	10	10.4	V/V
SS Pulldown Voltage	VOL_SS	0.1 mA into pin during ON delay		22		mV

## GOK OUTPUT

Output Low Voltage	VOL_GOK	IGOK = 1 mA			0.1	V
Off-state Leakage Current	ILK_GOK	VGOK = 5 V			1.0	$\mu$ A

Product parametric performance is indicated in the Electrical Characteristics for the listed test conditions, unless otherwise noted. Product performance may not be indicated by the Electrical Characteristics if operated under different conditions.

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Parameter	Symbol	Test Conditions	Min	Typ	Max	Units
<b>IMON/CS OUTPUT</b>						
IMON or CS Current (single EFuse) Based on 10 $\mu\text{A}/\text{A}+5 \mu\text{A}$	$I_{\text{IMON}}/I_{\text{CS}}$	$T_J = 0 \text{ to } 85^{\circ}\text{C}$	IOU = 5 A (Note 7)		55	$\mu\text{A}$
			IOU = 10 A (Note 7)		105	$\mu\text{A}$
			IOU = 25 A (Note 7)		255	$\mu\text{A}$
			IOU = 50 A (Note 7)		505	$\mu\text{A}$
Accuracy (single EFuse)		$T_J = 0 \text{ to } 85^{\circ}\text{C}$	IOU = 5 A (Note 7)	-6	+6	%
			IOU = 10 A (Note 7)	-4	+4	%
			IOU = 25 A (Note 7)	-4	+4	%
			IOU = 50 A (Note 7)	-4	+4	%
IMON or CS Current Source Clamp Voltage	$V_{\text{IM\_CLMP}}/V_{\text{CS\_CLMP}}$	Max pullup voltage of current source		3.0		V
Pre-Biased Offset Current Load for Auto-Zero Op-Amp	$I_{\text{AZ\_BIAS}}$			5.0		$\mu\text{A}$

## CURRENT LIMIT & CLREF PIN

Current Limit Voltage	VCL_TH	If $V_{\text{CS}} > V_{\text{CL\_TH}}$ current limiting regulation occurs via gate	95	98	101	% $V_{\text{CLREF}}$
Current Limit Clamp Voltage	VCL_LO	$V_{\text{OUT}} < 40\%$ , $V_{\text{IN}} V_{\text{CLREF}} > 0.15 \text{ V}$	135	152	165	mV
	VCL_HI	$40\% V_{\text{IN}} < V_{\text{OUT}} < 80\% V_{\text{IN}}$ $V_{\text{CLREF}} > 0.5 \text{ V}$	480	504	520	mV
Max Current Limit Reference Voltage	VCL_MX	$V_{\text{OUT}} > 80\% V_{\text{IN}}$ , $V_{\text{CLREF}} > 1.6 \text{ V}$	1.55	1.6	1.65	V
Response Time (Note 7)	$t_{\text{CL\_REG}}$	$V_{\text{CS}} > V_{\text{CLREF}}$ until current limiting		200		$\mu\text{s}$
CLREF Bias Current	$I_{\text{CL}}$	From pin into a 1.2 V source	9.6	10	10.4	$\mu\text{A}$
CLREF Current Source Clamp Voltage	$V_{\text{CL\_CLMP}}$	Max pullup voltage of current source		3.0		V
FET Turn-off Timer	$t_{\text{CL\_LA}}$	Delay between current limit detection and FET turn-off (GOK = 0)		250		$\mu\text{s}$

## D\_OC OUTPUT

Overcurrent Threshold	VOC_TH	If $V_{\text{CS}} > V_{\text{OC\_TH}}$ D_OC pin pulls low	83	86	90	% $V_{\text{CLREF}}$
Output Low Voltage	VOL_DOC	$I_{\text{DOC}} = 1 \text{ mA}$			0.1	V
Off-state Leakage Current	$I_{\text{LK\_DOC}}$	$V_{\text{DOC}} = 5 \text{ V}$	-		1.0	$\mu\text{A}$
Delay (rising) (Note 7)		$V_{\text{CS}} < \text{limit}$ until D_OC rising	-	1.0		$\mu\text{s}$
Delay (falling) (Note 7)		$V_{\text{CS}} > \text{limit}$ until D_OC falling	-	1.0		$\mu\text{s}$

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Parameter	Symbol	Test Conditions	Min	Typ	Max	Units
<b>SHORT CIRCUIT PROTECTION</b>						
Current Threshold (Note 7)	ISC	NCP81295		100		A
		NCP81296		80		A
Response Time (Note 7)	tSC	From IOUT > ILIMSC until gate pulldown		500		ns
<b>VTEMP OUTPUT</b>						
Bias Voltage	VVTEMP25	At 25°C		450		mV
Gain (Note 7)	AVTEMP	0°C ≤ TJ ≤ 125°C		10		mV/°C
Load Capability	RVTEMP	At 25°C		1		k $\Omega$
Pulldown Current	IVTEMP	At 25°C		50		$\mu$ A
<b>THERMAL SHUTDOWN</b>						
Temperature Shutdown (Note 7)	TSD	GOK pulls dow		140		°C
<b>OUTPUT SWITCH (FET)</b>						
On Resistance	RDSon	TJ = 25°C		0.65	1.0	m $\Omega$
Off-state leakage current	IDSoFF	VIN = 16 V, VON < 1.2 V, TJ = 25°C			1.0	$\mu$ A
<b>FAULT detection</b>						
VDS Short Threshold	VDS_TH	Startup postponed if VOUT > VDS_TH at VON > VSWON transition		88.8		%VIN
VDS Short OK Threshold	VDS_OK	Startup resumed if VOUT < VDS_OK anytime after postponed		68.6		%VIN
VGD Short Threshold	VDG_TH	Startup postponed if VG > VDG_TH at VON > VSWON transition		3.1		V
VGD Short OK Threshold	VDG_OK	Startup resumed if VG < VDG_OK anytime after postponed		3.0		V
VG Low Threshold	VG_TH	Latch/Restart if VGD < VG_TH after tSSF_END or tGATE_FLT		5.4		V
VOUT Low Threshold	VOUTL_TH	Latch/Restart if VOUT < VOUTL_TH after tSSF_END		90		%VIN
Gate Fault Timer (Note 7)	tGATE_FLT	Time from VGD < VG_TH transition after tSSF_END completed		200		ms
Startup Timer Failsafe (Note 7)	tSSF_END	Time from VON > VSWON transition, Max programmable softstart time		200		ms
<b>AUTO-RETRY (NCP81296)</b>						
Auto-Retry Delay	tDLY_RETRY	Delay from power-down to retry of startup		1000		ms

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## TYPICAL CHARACTERISTICS

Test Conditions:  $V_{in} = 12\text{ V}$ ,  $R_{cs} = 2\text{ k}\Omega$ ,  $C_{ss} = 200\text{ nF}$ ,  $R_{CLREF} = 121\text{ k}\Omega$ ,  $R_{IMON} = 2\text{ k}\Omega$

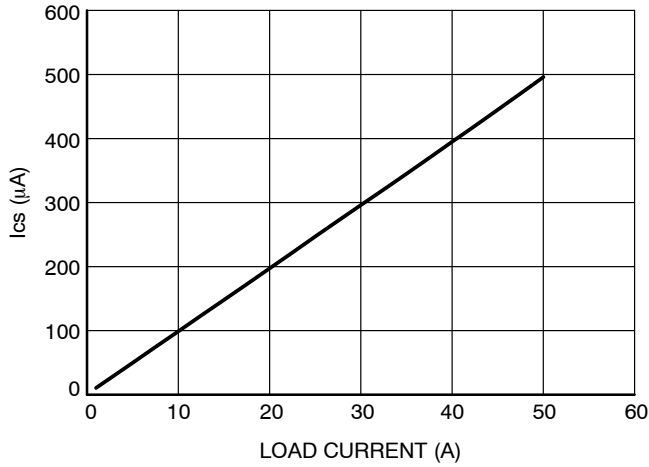


Figure 8. Ics vs. Load Current

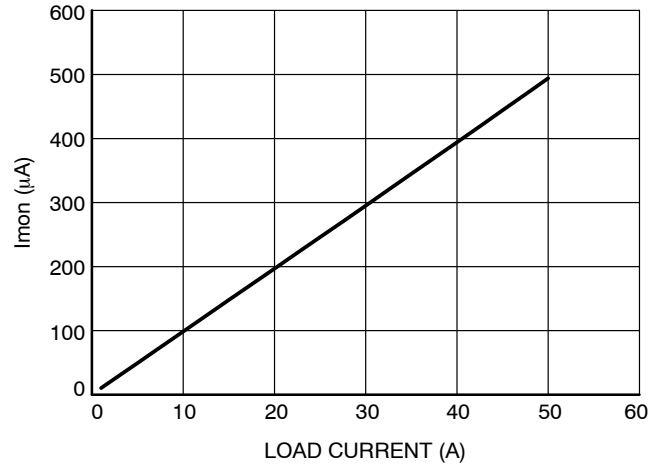


Figure 9. Imon vs. Load Current

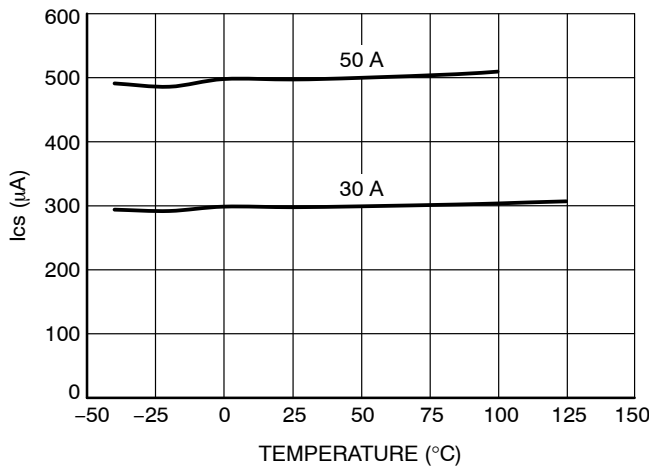


Figure 10. Ics vs. Temperature

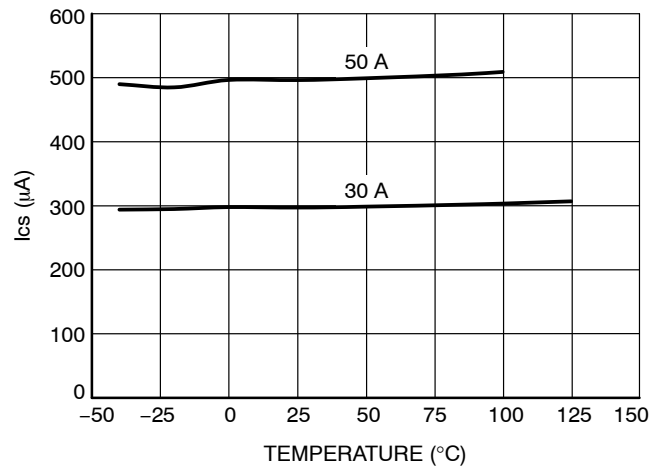


Figure 11. Imon vs. Temperature

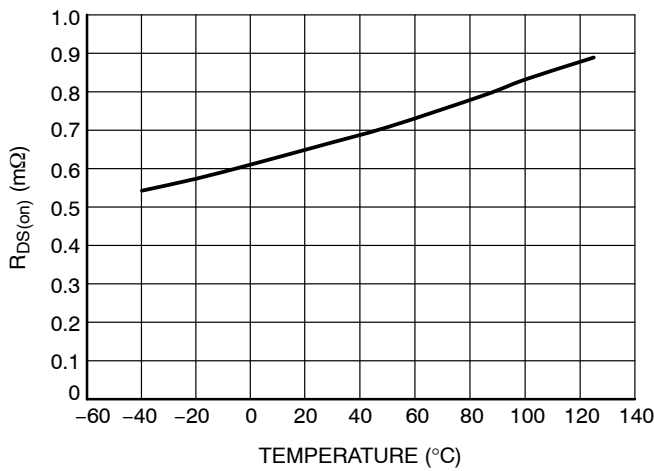


Figure 12. Output Switch  $R_{DS(on)}$  @ 22 A vs. Temperature

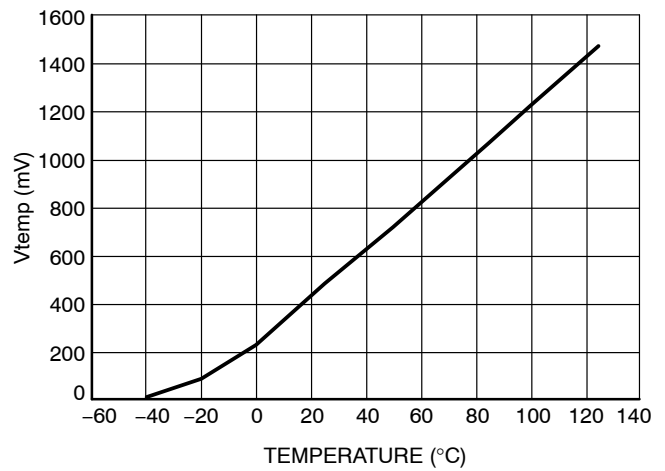
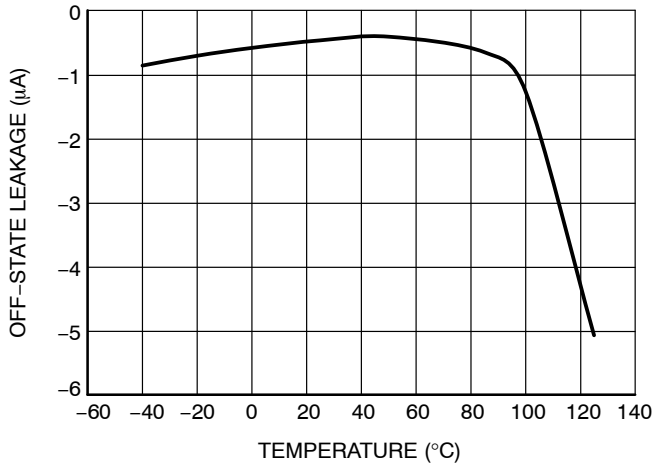


Figure 13. Vtemp vs. Temperature (no load)

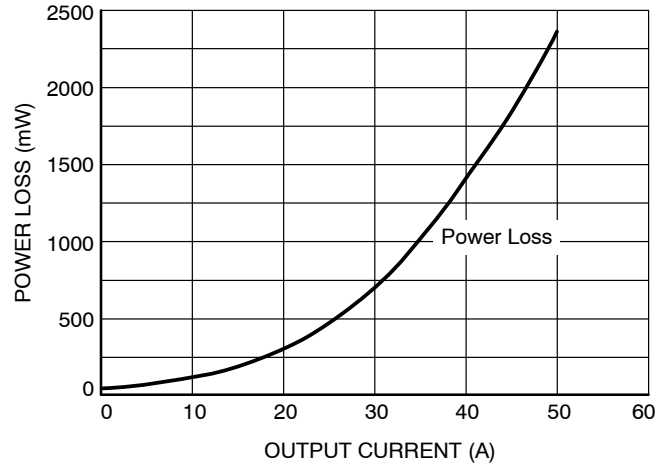
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## TYPICAL CHARACTERISTICS

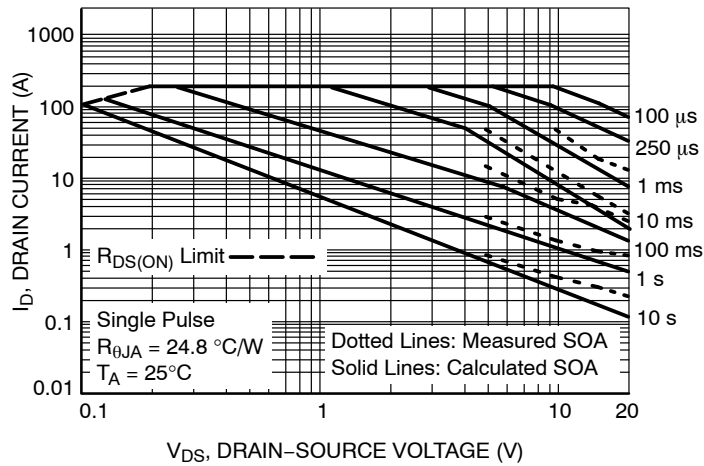
Test Conditions:  $V_{in} = 12\text{ V}$ ,  $R_{cs} = 2\text{ k}\Omega$ ,  $C_{ss} = 200\text{ nF}$ ,  $R_{CLREF} = 121\text{ k}\Omega$ ,  $R_{IMON} = 2\text{ k}\Omega$



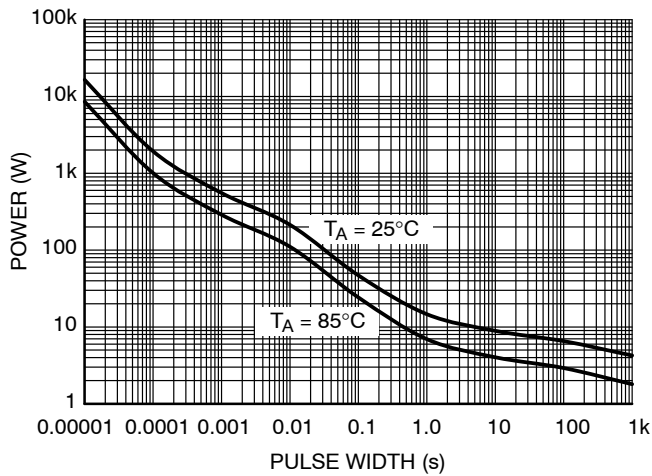
**Figure 14. Output Switch Off-state Leakage vs. Temperature**



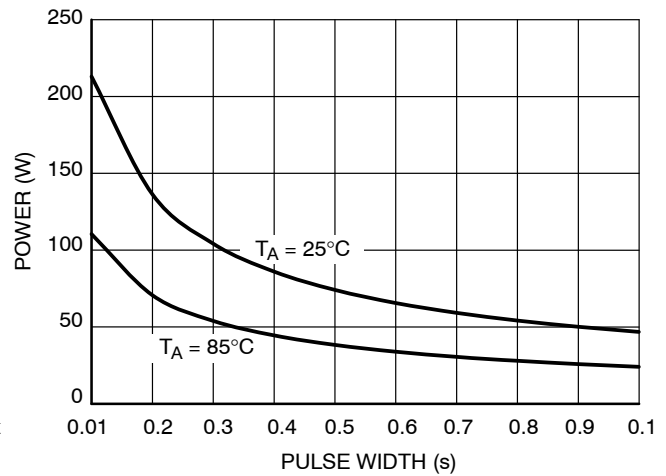
**Figure 15. Power Loss vs. Load Current**



**Figure 16. Internal FET's Safe Operating Area (SOA)**



**Figure 17. Single Pulse Power Rating (10  $\mu\text{s}$  – 1000 s, Junction-to-Ambient, Note 4)**



**Figure 18. Single Pulse Power Rating (10 ms – 100 ms, Junction-to-Ambient, Note 4)**

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## TYPICAL CHARACTERISTICS

Test Conditions:  $V_{in} = 12\text{ V}$ ,  $R_{cs} = 2\text{ k}\Omega$ ,  $C_{ss} = 200\text{ nF}$ ,  $R_{CLREF} = 121\text{ k}\Omega$ ,  $R_{IMON} = 2\text{ k}\Omega$

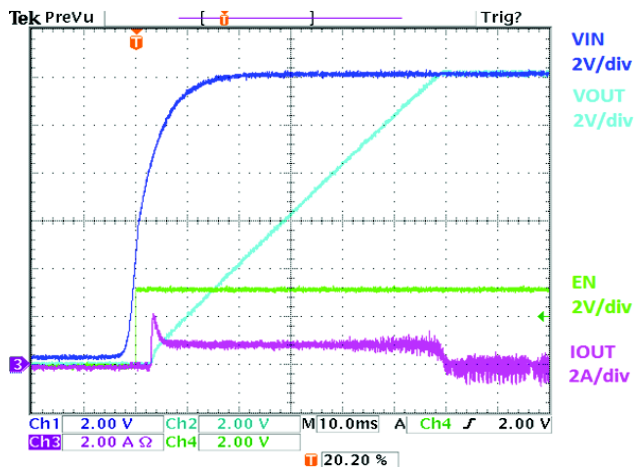


Figure 19. Start Up by VIN (Iout = 0 A)

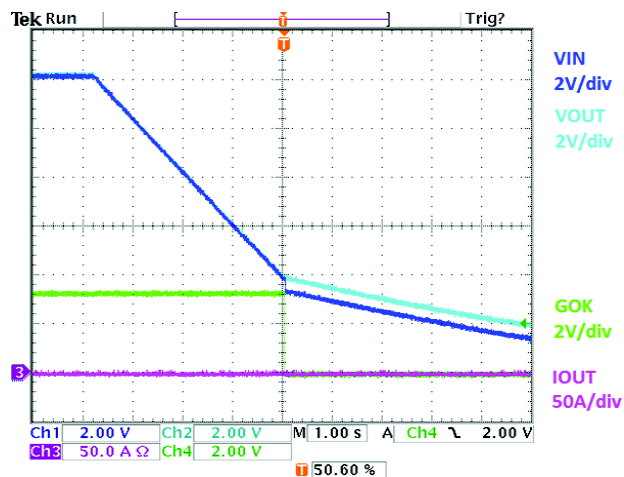


Figure 20. Shut Down by VIN (Iout = 0 A)

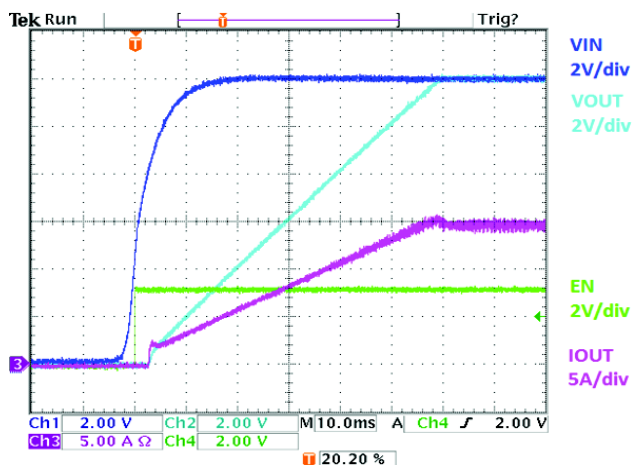


Figure 21. Start Up by VIN (Iout = 15 A)

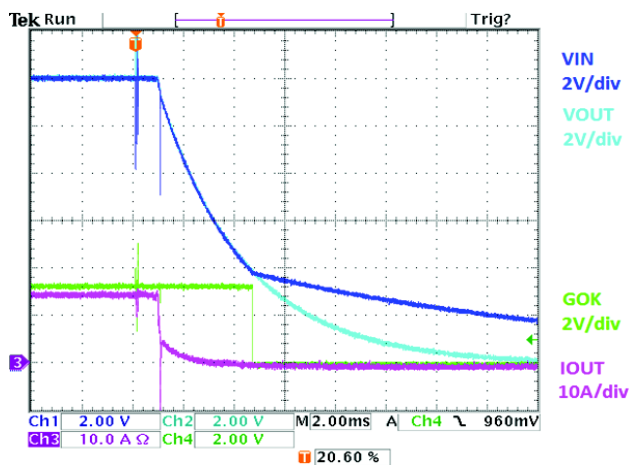


Figure 22. Shut Down by VIN (Iout = 15 A)

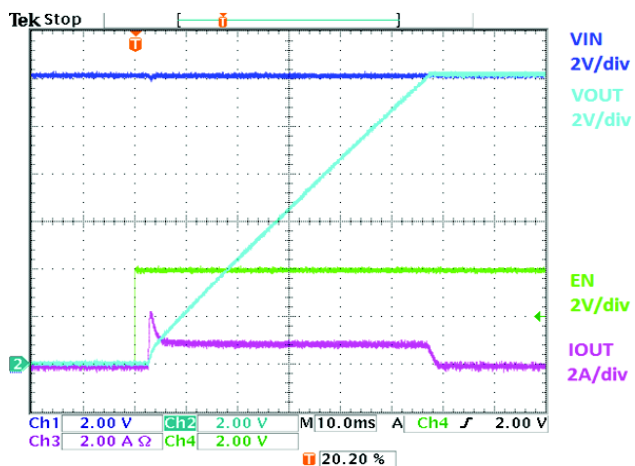


Figure 23. Start Up by EN (Iout = 0 A)

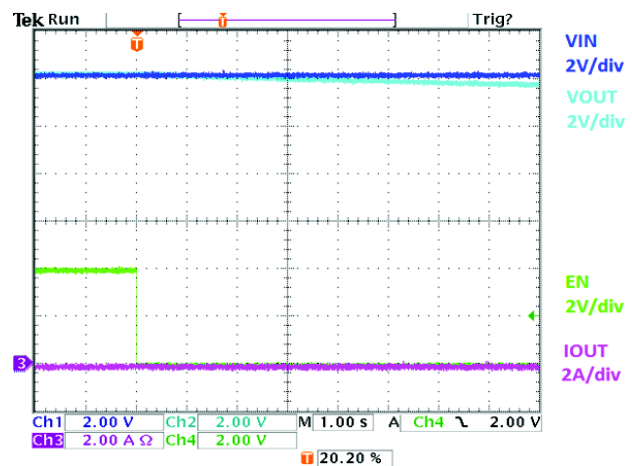


Figure 24. Shut Down by EN (Iout = 0 A)

# NCP81295, NCP81296

## TYPICAL CHARACTERISTICS

Test Conditions:  $V_{in} = 12\text{ V}$ ,  $R_{cs} = 2\text{ k}\Omega$ ,  $C_{ss} = 200\text{ nF}$ ,  $R_{CLREF} = 121\text{ k}\Omega$ ,  $R_{IMON} = 2\text{ k}\Omega$

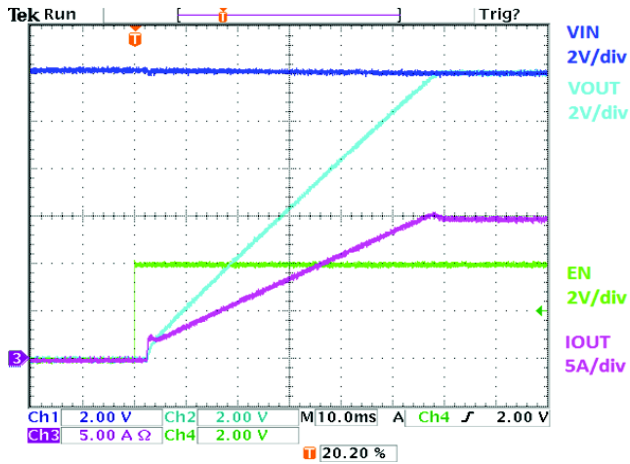


Figure 25. Start Up by EN ( $I_{out} = 15\text{ A}$ )

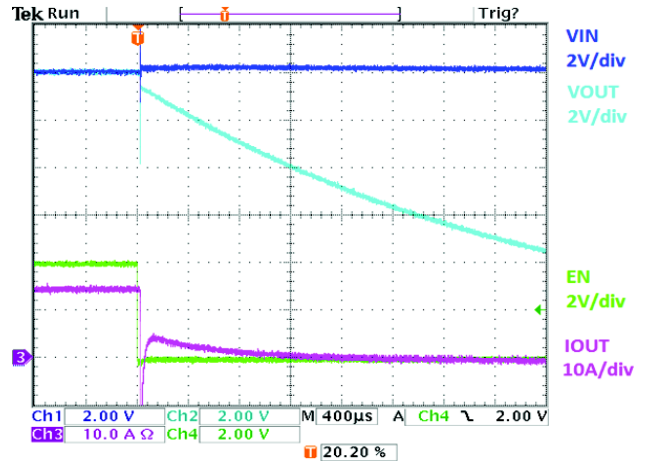


Figure 26. Shut Down by EN ( $I_{out} = 15\text{ A}$ )

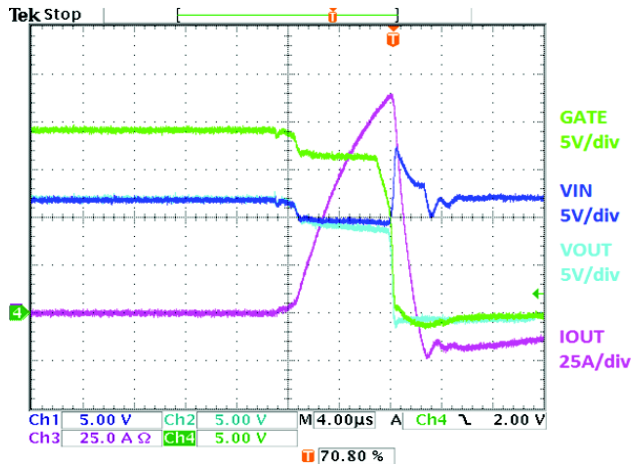


Figure 27. Short Circuit during Normal Operation ( $I_{out} = 0\text{ A}$ )

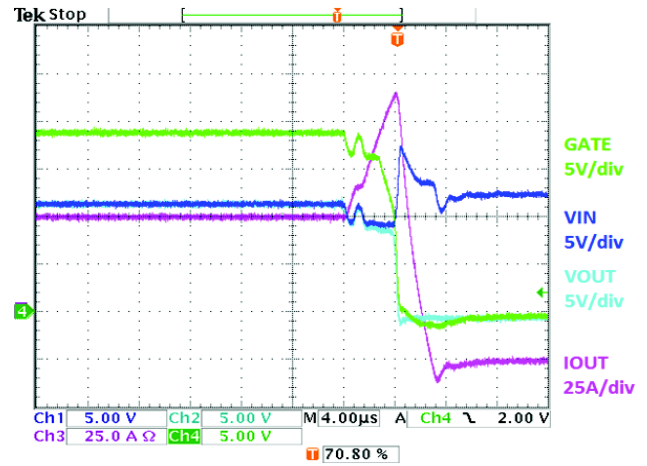


Figure 28. Short Circuit during Normal Operation ( $I_{out} = 50\text{ A}$ )

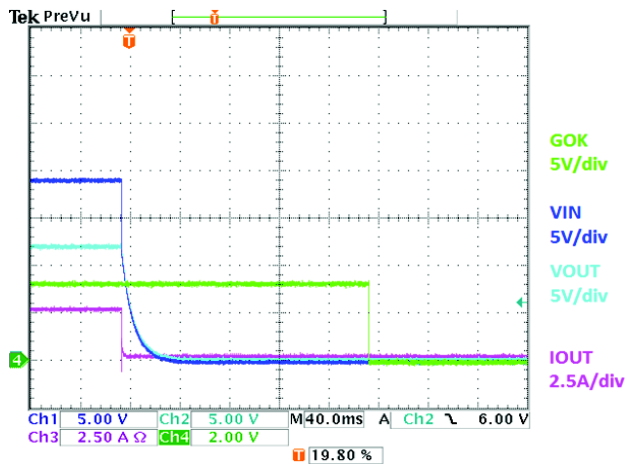


Figure 29. Short FET's Gate During Normal Operation ( $I_{out} = 2.5\text{ A}$ )

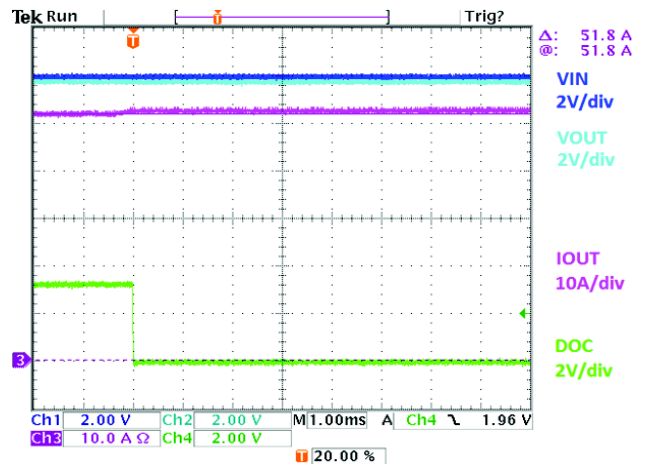


Figure 30. DOC Index for Current Limit during Normal Operation ( $I_{out} = 51.8\text{ A}$ )

# NCP81295, NCP81296

## TYPICAL CHARACTERISTICS

Test Conditions:  $V_{in} = 12\text{ V}$ ,  $R_{cs} = 2\text{ k}\Omega$ ,  $C_{ss} = 200\text{ nF}$ ,  $R_{CLREF} = 121\text{ k}\Omega$ ,  $R_{IMON} = 2\text{ k}\Omega$

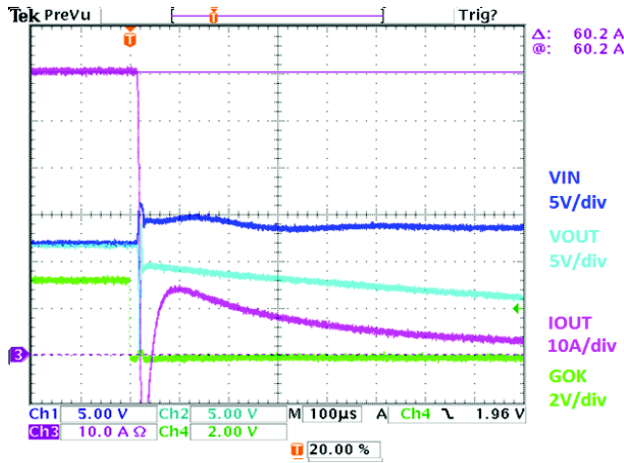


Figure 31. OCP during Normal Operation( $I_{out}=60.2\text{A}$ )

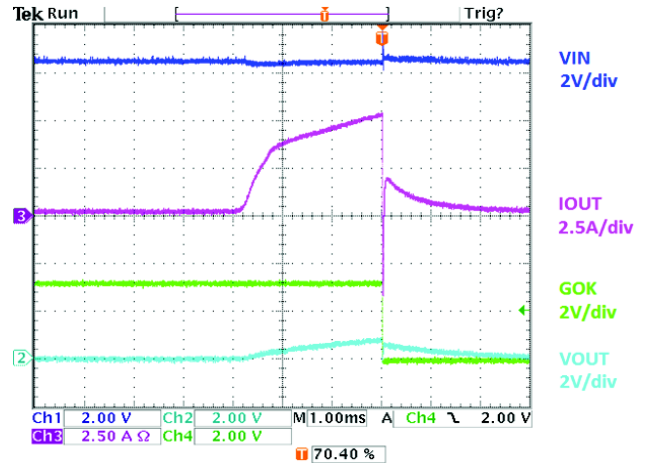


Figure 32. OCP during Power Up by Enable



## General Information

The NCP81295/6 is an N-channel MOSFET co-packaged with a smart hotswap controller. It is suited for high-side current limiting and fusing in hot-swap applications. It can be used either alone, or in a parallel configuration for higher current applications.

## VDD Output (Auxiliary Regulated Supply)

An internal linear regulator draws current from the VIN pin to produce and regulate voltage at the VDD pin. This auxiliary output supply is current-limited to  $I_{DD\_CL}$ . A ceramic capacitor in the range of 2.2  $\mu\text{F}$  to 10  $\mu\text{F}$  must be placed between the VDD and GND pins, as close to the NCP81295/6 as possible.

## ON Input (Device Enable)

When the ON pin voltage ( $V_{ON}$ ) is higher than  $V_{SWON}$ , and no undervoltage (UVLO) or output switch faults are present, the output switch turns on. When  $V_{ON}$  is lower than  $V_{SWOFF}$ , the output switch is off. If  $V_{ON}$  is between  $V_{PDOFF}$  and  $V_{SWOFF}$  for longer than  $t_{PD\_DEL}$ , the output switches off, and a pulldown resistance to ground, of  $R_{PD}$ , is applied to VOUT.

For standalone applications, the ON pin sources current  $I_{ON}$ , which can be used to delay output switch turn-on for some time after the appearance of input voltage by connecting a capacitor from the ON pin to ground.

A bi-level control signal driving to ground can be biased up with a resistive divider to produce ON input levels between  $V_{PDOFF} < V_{ON} < V_{SWON}$  and  $V_{ON} > V_{SWON}$  in order to always apply the output pulldown when the output switch is off.

## SS Output (Soft-Start)

When the output switch first turns on, it does so in a controlled manner. The output voltage (VOUT) follows the voltage at the SS pin, produced by current  $I_{SS}$  into a capacitor from SS to ground. The duration of soft-start can be programmed by selection of the capacitor value. In parallel fuse applications, the SS pins of all fuses should be shorted together to one shared SS capacitor. Internal soft-start load balancing circuitry will ensure the soft-start current is shared between paralleled devices, so as not to stress one device more than another or hit a soft start-current limit.

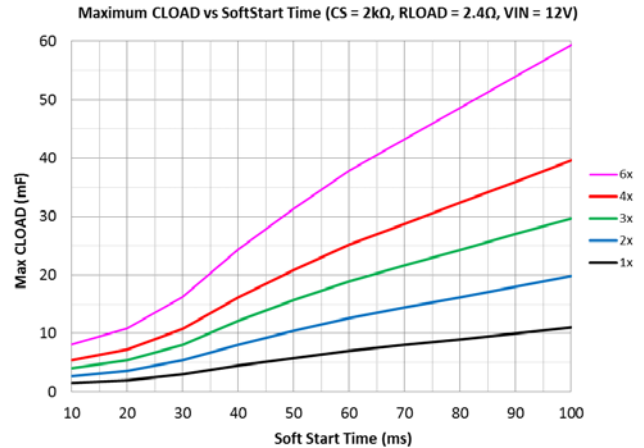
The soft-start capacitor value can be calculated by:

$C_{SS} = (t_{SS} * I_{SS} * AV_{SS})/V_{IN}$  (where  $t_{SS}$  is the target soft-start time). The recommended range of  $t_{SS}$  is 10 – 100 ms (see Table 5).

The typical  $C_{SS}$  values for different  $t_{SS}$  are listed below:

$t_{SS}$ (ms)	$C_{SS}$ (nF)	$t_{SS}$ (ms)	$C_{SS}$ (nF)
10	47	60	270
20	82	70	330
30	120	80	330
40	180	90	470
50	220	100	470

The maximum load capacitor value NCP81295/6 can power up depends on the device soft-start time. When  $V_{IN} = 12\text{ V}$ ,  $R_{CS} = 2\text{ k}\Omega$ ,  $R_{LOAD} = 2.4\text{ }\Omega$ , their relationship for different paralleled operations are shown as below chart (above line device shuts down safely due to protection, below line device powers up successfully without trigger protection):



## GOK Output (Gate OK)

The GOK pin is an open-drain output that is pulled low to report the fault under the following conditions:

- $V_{DD}$  voltage is below UVLO voltage at any time.
- $V_{ON}$  disabled and  $V_{DS\_OK}$  is false (indicates a short from  $V_{IN}$  to VOUT).
- $V_{ON}$  disabled and  $V_{DG\_OK}$  is false (indicates a short from GATE to  $V_{IN}$ ).
- $V_{ON}$  enabled and  $V_{SS\_OK}$  is false at  $t_{SS\_END}$  (indicates  $V_{OUT} < 90\%$  after soft-start completes – FET latches off for NCP81295/auto-retries for NCP81296).
- $V_{ON}$  enabled and  $V_G$  is below  $V_{G\_TH}$  at  $t_{SS\_END}$  (indicates leakage on GATE in startup – FET latches off for NCP81295/auto-retries for NCP81296).
- $V_{ON}$  enabled and  $V_G$  is below  $V_{G\_TH}$  after  $t_{GATE\_FLT}$  (indicates leakage on GATE during normal operation – FET latches off for NCP81295/auto-retries for NCP81296).
- $V_{ON}$  enabled and a current-limiting condition lasts longer than  $t_{OC\_LA}$  (FET latches off for NCP81295/auto-retries for NCP81296).
- $V_{ON}$  enabled and device temperature is above  $T_{TSD}$  (indicates an over-temperature is detected – FET latches off for NCP81295/auto-retries for NCP81296).

Usually GOK can't be used as power good to indicate the output voltage is in the normal range. Bringing VDD below the UVLO voltage is required to release a latching condition.

### IMON Output (Current Monitor)

The IMON pin sources a current that is  $A_{IMON}$  times the VOUT output current. A resistor connected from the IMON pin to ground can be used to monitor current information as a voltage up to  $V_{IM\_CLMP}$ . A capacitor of any value in parallel with the IMON resistor can be used to low-pass filter the IMON signal without affecting any internal operation of the device.

### CLREF Pin (Current Limit and Over-Current Reference)

The CLREF pin voltage determines the current-limit regulation point and over-current indication point via its interaction with the CS pin voltage. The CLREF voltage can be applied by an external source, such as a hot-swap controller or D-to-A converter, or developed across a programming resistor to ground by the CLREF bias current,  $I_{CL}$ . The recommended range of CLREF voltage is 0.2 – 1.4 V (see Table 5).

### CS Input/Output (Current Set)

The CS pin is both an input and an output. The CS pin sources a current that is  $A_{CS}$  times the VOUT current. This produces a voltage on the CS pin that is the product of the CS pin current and an external CS pin resistance to ground.

The voltage generated on  $V_{CS}$  determines the D\_OC over-current indicator trip point and the current-limit regulation point, via its interaction with the voltage on CLREF pin.

When the voltage on the CS pin is higher than  $V_{OC\_TH}$ , D\_OC is pulled low. If the CS pin voltage drops below  $V_{OC\_TH}$ , the D\_OC pin is released to and gets pulled high by the external pullup resistor. D\_OC transitions based on the following formula:  $I_{OUT} = V_{OC\_TH} / (R_{CS} * A_{CS})$ . The  $V_{OC\_TH}$  trip point is based on a percentage of  $V_{CLREF}$  (85%).

During normal operation ( $V_{ON} > V_{SWON}$  for longer than  $t_{SS\_END}$ ), if the voltage on the CS pin is above  $V_{CL\_TH}$  ( $V_{CL\_TH}$  is clamped at  $V_{CL\_MX}$  if  $V_{CL\_TH} > V_{CL\_MX}$ ), then the gate voltage of the FET is modulated to limit current into the output based on the following formula:

$I_{OUT} = V_{CL\_TH} / (R_{CS} * A_{CS})$ . The  $V_{CL\_TH}$  regulation point is equal to  $V_{CLREF}$ .

During startup ( $V_{ON} > V_{SWON}$  for less than  $t_{SS\_END}$ ), the current limit reference voltage is clamped according to the following:

- When  $V_{OUT} < 40\%$  of  $V_{IN}$ ,  $V_{CL\_TH} = V_{CL\_LO}$  or  $V_{CLREF}$  (whichever is lower).
- When  $V_{OUT}$  is between 40% and 80% of  $V_{IN}$ ,  $V_{CL\_TH} = V_{CL\_HI}$  or  $V_{CLREF}$  (whichever is lower).
- When  $V_{OUT}$  exceeds 80% of  $V_{IN}$ ,  $V_{CL\_TH} = V_{CL\_MX}$  or  $V_{CLREF}$  (whichever is lower).

If a current limiting condition exists anytime for a continuous duration  $> t_{CL\_LA}$ , then the device latches off (NCP81295) or restarts (NCP81296).

The CS pin must have no capacitive loading other than parasitic device/board capacitance to function correctly. The recommended range of  $R_{CS}$  is 1.8 – 4 k $\Omega$  (see Table 5).

### CS AMP OFFSET BIAS

NCP81295/6 use an auto-zero Op-Amp with low input offset to sense current in FET with high-accuracy, and an pre-biased offset current load,  $I_{AZ\_BIAS}$  is need for this Op-Amp to always keep it to maintain this low input offset ( $<100 \mu V$ ). The internal IMON and CS current source follow below relationship:

$$I_{OUT} = \frac{I_{CS} - I_{AZ\_BIAS}}{10 \mu} \quad (\text{eq. 1})$$

and

$$I_{OUT} = \frac{I_{MON} - I_{AZ\_BIAS}}{10 \mu} \quad (\text{eq. 2})$$

For typical 5  $\mu A$   $I_{AZ\_BIAS}$ , there has 0.5 A positive off-set in  $I_{OUT}$  sense.

### D\_OC Output (Over-current Indicator)

The D\_OC pin is an open-drain output that indicates when an over-current condition exists after soft-start is complete. When the voltage on the CS pin is higher than  $V_{OC\_TH}$ , D\_OC is pulled low. If output current drops below  $V_{OC\_TH}$ , the D\_OC pin is released and gets pulled high by an external pullup resistor.

### VTEMP Output (Temperature Indicator)

VTEMP is a voltage output proportional to device temperature, with an offset voltage. The VTEMP output can source much more current than it can sink, so that if multiple VTEMP outputs are connected together, the voltage of all VTEMP outputs will be driven to the voltage produced by the hottest NCP81295/6. A 100 nF capacitor or greater must be connected from the VTEMP pin to ground.

### Auto-Retry Restart (NCP81296)

Under certain fault conditions, the FET is turned off and another soft-start procedure takes place. Between the fault and the new soft-start, there is a delay of  $t_{DLY\_RETRY}$ . The protection features that use this hiccup mode restart are:

- Over-Current
- Short-Circuit Detection
- Over-Temperature
- Excessive Soft-Start Duration
- Gate Leakage

### Protection Features

For the following protection features, the FET either latches off (NCP81295) or the FET turns off and initiates a restart (NCP81296), unless noted otherwise.

## NCP81295, NCP81296

### Excessive Current Limiting

If a current limiting condition exists anytime for a continuous duration  $> t_{CL\_LA}$ , then the FET latches/restarts.

### Excessive Soft-Start Duration

If  $V_{OUT} < V_{OUTL\_TH}$  when  $t_{SSF\_END}$  expires, then the FET latches/restarts.

### Short Circuit Detection

If switch current exceeds  $I_{SC}$ , the device reacts within  $t_{SC}$ , and the FET latches/restarts. The short-circuit current monitor is independent of CS, CLREF, IMON and current limit setting (cannot be changed externally).

### Over-Temperature Shutdown

If the FET controller temperature  $> T_{TSD}$ , then the FET latches/restarts.

### FET Fault Detection

The device contains various FET monitoring circuits:

- VIN to VOUT short, non-latching/non-auto-retry condition. If the device is disabled and  $V_{OUT} > V_{DS\_TH}$  then GOK is pulled low and the device is prevented from powering up. The device is allowed to power up once  $V_{OUT} < V_{DS\_OK}$ .
- GATE to VIN short, non-latching/non-auto-retry condition. If the device is disabled and

$GATE (Pin 8) > V_{DG\_TH}$ , then GOK is pulled low and device is prevented from powering up. The device allowed to power up once  $GATE < V_{DG\_OK}$ .

- GATE leakage – startup.  
If  $(GATE - V_{INF}) < V_{G\_TH}$  at  $t_{SSF\_END}$ , then GOK is pulled low and FET latches/restarts.
- GATE leakage – normal operation.  
If  $(GATE - V_{INF}) < V_{G\_TH}$  for  $t_{GATE\_FLT}$  time after the soft-start timer completes, then GOK is pulled low and device latches/restarts.

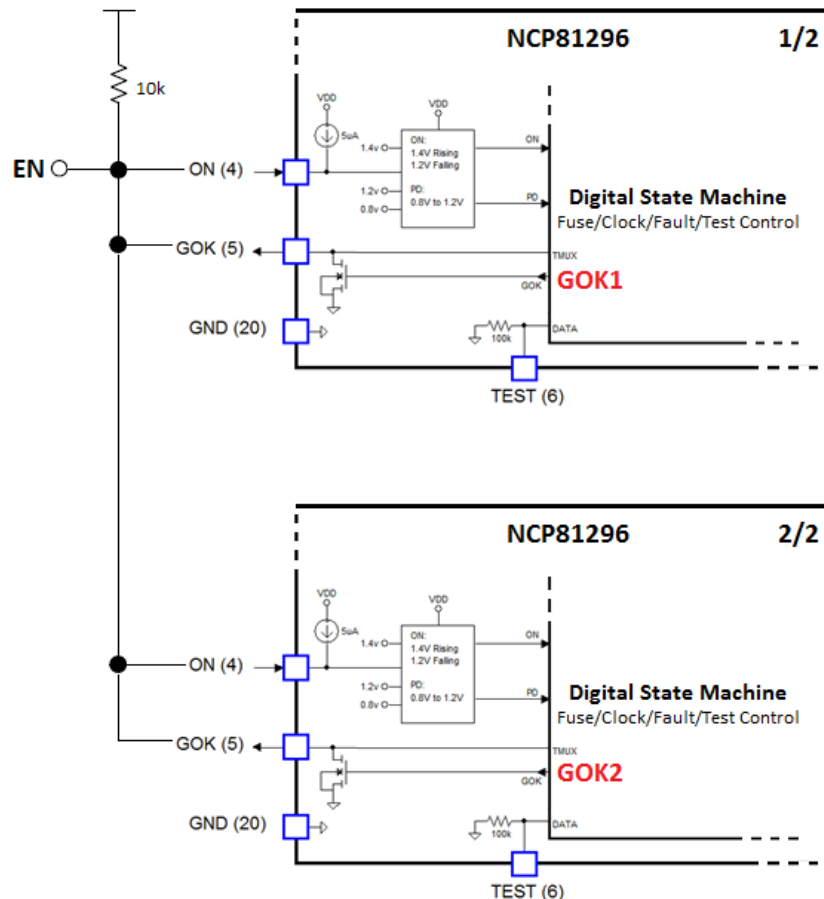
### FET SOA Limits

In-built timed current limits and fault-monitoring circuits ensure the copackaged FET is always kept within SOA limits.

### Multiple Fuse Power Up

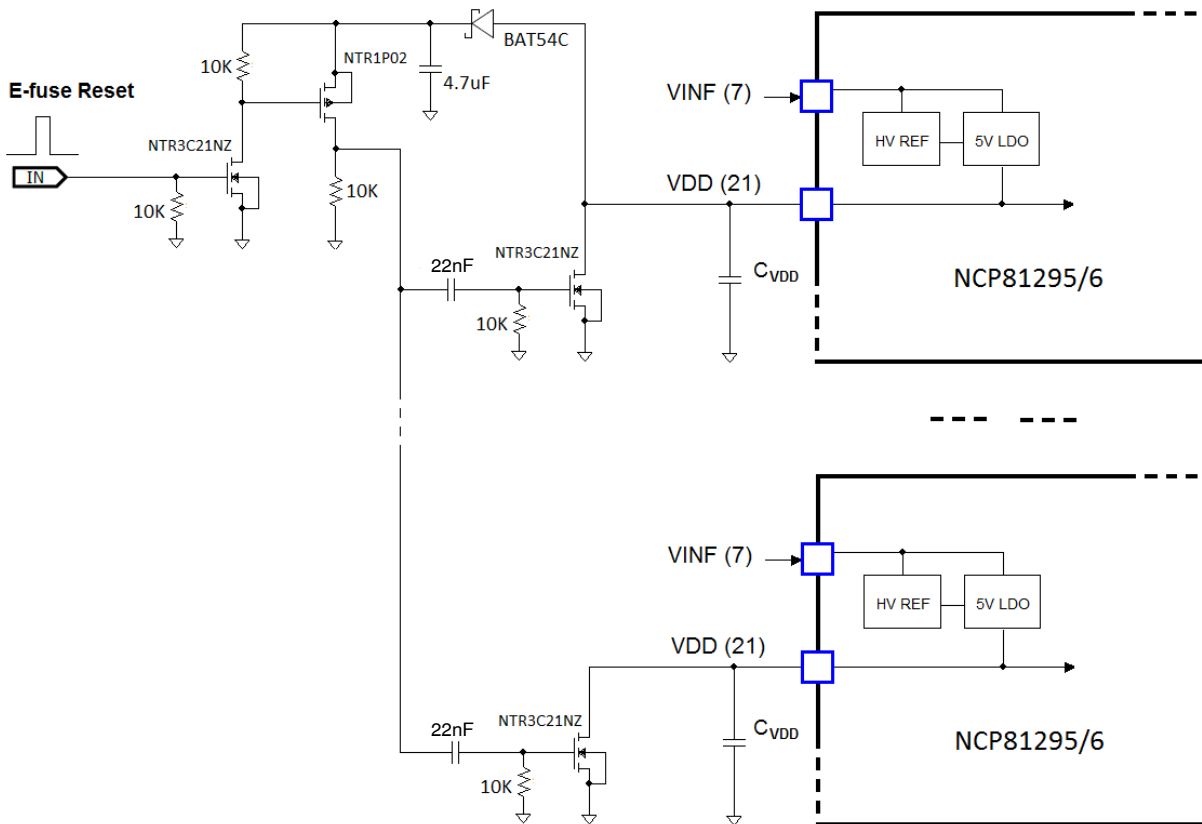
When multiple NPC81295 are paralleled together as shown in Figure 4, the NPC81295s will turn on together. Keeping the current through each switch within 1 A (typical) helps to prevent overstress on each switching during soft-start.

**Due to NCP81296 is featured by Auto-Retry Mode protection, please follow the below reference schematic of NCP81296 for paralleled operation.**



## NCP81295, NCP81296

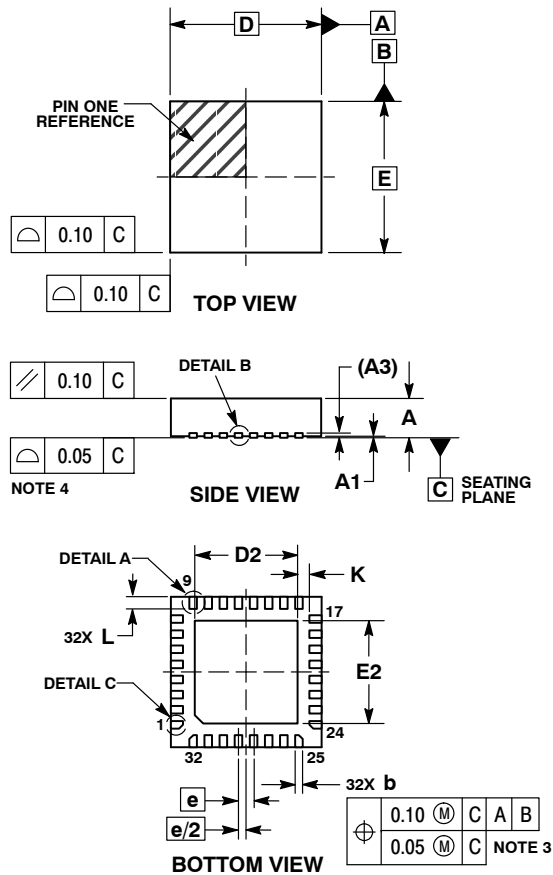
When paralleled multiple NCP81295 encounter fault, the system can recover the E-fuse by resetting their VDD with below buffer and reset circuit.



# NCP81295, NCP81296

## PACKAGE DIMENSIONS

LQFN32 5x5, 0.5P  
CASE 487AA  
ISSUE A

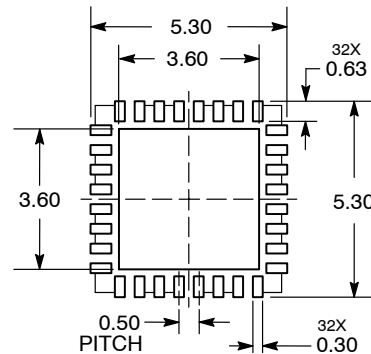


### NOTES:

1. DIMENSIONING AND TOLERANCING PER ASME Y14.5M, 1994.
2. CONTROLLING DIMENSION: MILLIMETERS.
3. DIMENSION b APPLIES TO PLATED TERMINAL AND IS MEASURED BETWEEN 0.15 AND 0.30 MM FROM THE TERMINAL TIP.
4. COPLANARITY APPLIES TO THE EXPOSED PAD AS WELL AS THE TERMINALS.

MILLIMETERS		
DIM	MIN	MAX
A	1.20	1.40
A1	---	0.05
A3	0.20	REF
b	0.18	0.30
D	5.00	BSC
D2	3.30	3.50
E	5.00	BSC
E2	3.30	3.50
e	0.50	BSC
L	0.30	0.50
L2	0.13	REF

### RECOMMENDED SOLDERING FOOTPRINT\*



\*For additional information on our Pb-Free strategy and soldering details, please download the ON Semiconductor Soldering and Mounting Techniques Reference Manual, SOLDERRM/D.

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