

## GENERAL DESCRIPTION

MX26631DL is a 40V industrial eFuse solution. The device provides robust protection for all systems and applications powered from 4.5V to 40V. For hot-pluggable boards, the device provides hot-swap power management with in-rush current control and programmable output voltage slew rate features using the dVdT pin. Load, source, and device protections are provided with many programmable features including overcurrent, overvoltage and undervoltage. The precision overcurrent limit helps to minimize over design of the input power supply, while the fast response short circuit protection immediately isolates the faulty load from the input supply when a short circuit is detected. The device features fast reverse current blocking response. The internal robust protection control blocks of the MX26631DL along with its 40V rating, helps to simplify the system designs for the industrial surge compliance ensuring complete protection of the load and the device.

## APPLICATIONS

Industrial Applications

Servers

Networking

Electronics breakers

## FEATURES

◆UL\_IEC\_62368 certified

UL Certification Number: E537785

◆4.5V to 40V operating input range

◆Internal 60V, 30mΩ Ron hot-swap N-Channel FET

◆Reverse blocking current in 0.2us

◆Integrated current sensing with sense output

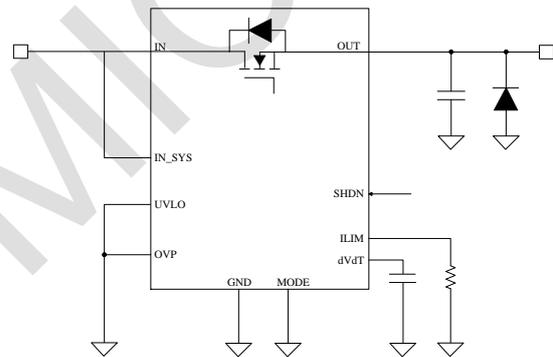
◆Adjustable current limit from 0.6A to 6A

◆Adjustable UVLO, OVP cutoff, output slew rate control for inrush current limiting

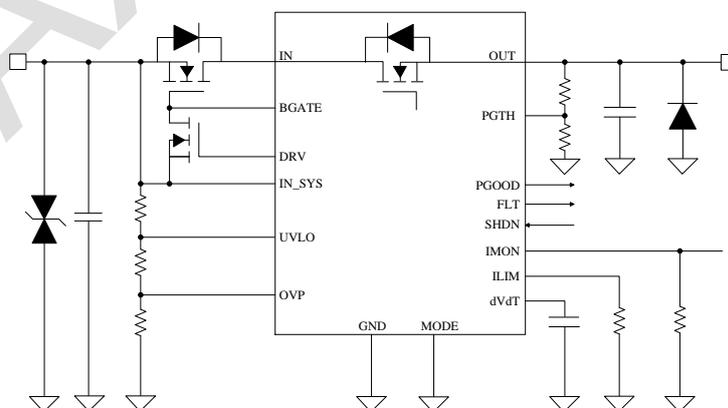
◆Power Good Output (PGOOD)

◆ Overcurrent fault response with auto-retry

◆Models with 1.5x pulsed overcurrent support



Minimum system application



**40V, 5A, 30mΩ Hot-Swap eFuse Solution**

## General information

### Ordering information

Part Number	Description
MX26631DL	QFN4*4-24L, Halogen-free, RoHS

### Package dissipation rating

Package	R <sub>θJA</sub> (°C/W)	R <sub>θJC</sub> (°C/W) (top)
QFN4*4-24L	32	23

### Absolute maximum ratings

Parameter	Value
IN, IN_SYS, OUT, UVLO, $\overline{\text{FLT}}$ , PGOOD, PGTH	-0.3~60V
IN, IN_SYS (10ms transient)	-0.3~65V
BGATE	-0.3~65V
DRV	-0.3~65V
DRV - IN_SYS	-0.3~15V
OVP, dVdT, I <sub>MON</sub> , MODE, $\overline{\text{SHDN}}$ , I <sub>LIM</sub>	-0.3~5.5V
Junction temperature T <sub>J</sub>	-40 to 150°C
Ambient temperature T <sub>A</sub>	-40 to 85°C
Storage temperature T <sub>STG</sub>	-55 to 150°C
ESD(HBM)	±2.0kV
Leading temperature (soldering, 10secs)	260°C

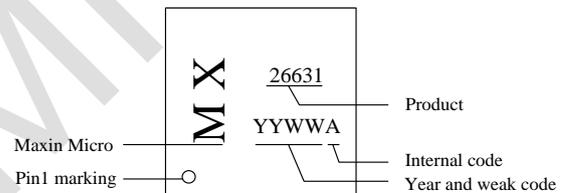
Note: stresses beyond those listed under “absolute maximum ratings” may cause permanent damage to the device. These are stress ratings only, functional operation of the device at these

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.

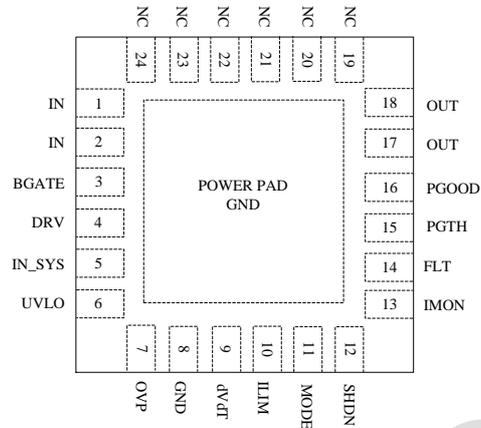
### Recommended operating condition

Symbol	Parameter	Range
IN_SYS, IN	Input Voltage	4.5~40V
OUT, UVLO, PGTH, PGOOD, $\overline{\text{FLT}}$		0~40V
OVP, dVdT, IMON, MODE, $\overline{\text{SHDN}}$		0~5V
ILIM	Resistance	5~100kΩ
IMON		≥1kΩ
IN, IN_SYS, OUT	Capacitance	≥100nF
dVdT		

### Marking Information

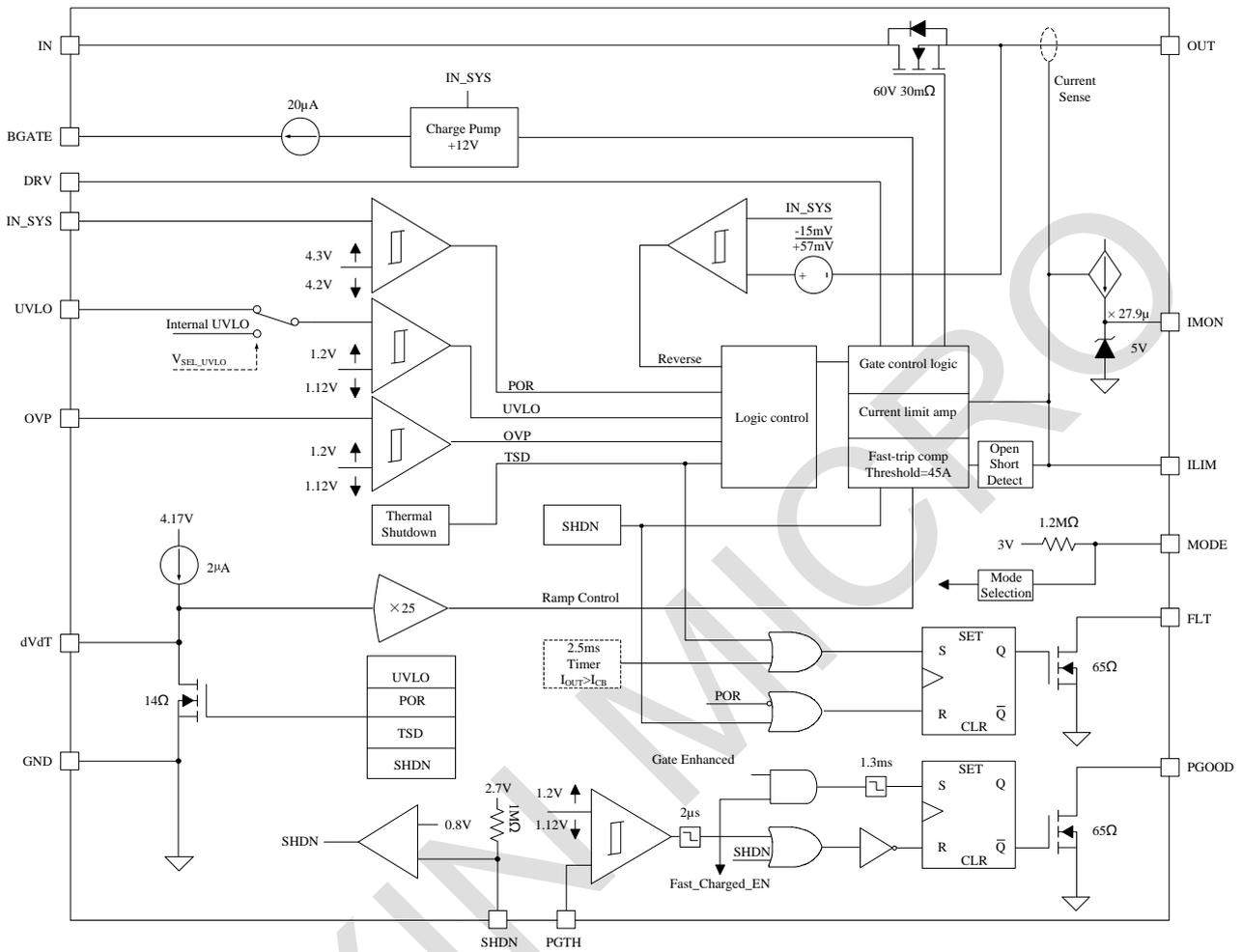


## Terminal assignments



PIN NO.	PIN name	Description
1/2	IN	Power input. Connect to the Drain of the internal FET.
3	BGATE	Blocking FET gate driver output. Connect to GATE of the external FET. If external FET is not used, then leave BGATE pin floating.
4	DRV	Blocking FET fast pull-down switch drive. Connect DRV to the GATE of external pull-down switch. Leave this pin floating if external FET is not used
5	IN_SYS	Power input and supply voltage of the device. Short IN_SYS to IN in case blocking FET is not used.
6	UVLO	Input for setting the programmable UVLO threshold. Connect UVLO pin to GND to select the internal default threshold.
7	OVP	Input for setting the programmable OVP threshold. Connect to GND if OVP not used.
8	GND	System ground pin.
9	dVdT	A capacitor from this pin to GND sets output voltage slew rate.
10	ILIM	A resistor from this pin to GND sets overload and short circuit current limit.
11	MODE	Mode selection for ILIM pin short protection mode. This pin is pulled up internal.
12	$\overline{\text{SHDN}}$	Pulling $\overline{\text{SHDN}}$ pin low makes the device to enter shutdown mode. Cycling $\overline{\text{SHDN}}$ pin voltage resets the device that fast latched off due to a fault condition.
13	IMON	Analog current monitor. A resistor from this pin to GND converts current to voltage. If unused, leave it floating.
14	$\overline{\text{FLT}}$	Fault event indicator. It is an open drain output. If unused, leave floating or connect to GND.
15	PGTH	PGOOD comparator input.
16	PGOOD	Active high. A high indicates PGTH has crossed the $V_{\text{PGTHR}}$ threshold, and the internal driver is high. PGOOD goes low when $V_{\text{PGTH}}$ hits $V_{\text{PGTHF}}$ threshold. If PGOOD is unused connect to GND or leave it floating.
17/18	OUT	Power output of the device.
19-24	NC	No connect.
Power Pad		Ground.

**Block Diagram**



## Electrical characteristics

$4.5V \leq V_{IN} \leq 40V$ ,  $V_{SHDN} = 2V$ ,  $R_{ILIM} = 10k\Omega$ ,  $UVLO = OVP = 0V$ ,  $C_{OUT} = 1\mu F$ ,  $C_{dVdT} = OPEN$ . (Unless otherwise noted)

Symbol	Parameter	Test condition	Min	Typ.	Max	Unit
<b>IN_SYS supply voltage</b>						
$V_{IN\_SYS}$	Operating input voltage		4.5		40	V
$I_{QON}$	Supply current	$\overline{SHDN} = 3V$ enable	0.5	1.0	1.5	mA
$I_{QOFF}$	Supply current	$SHDN = 0V$ disable	5	25	50	$\mu A$
<b>Under Voltage Lockout Input</b>						
UVLO	Internal undervoltage trip level	IN_SYS rising UVLO=GND	14.8	15.4	16.0	V
		IN_SYS falling UVLO=GND	14.0	14.6	14.8	V
$V_{SEL\_UVLO}$	Internal UVLO select threshold		180	210	240	mV
$V_{UVLOR}$	UVLO threshold voltage, rising		1.18	1.21	1.28	V
$V_{UVLOF}$	UVLO threshold voltage, falling		1.10	1.17	1.25	V
$I_{UVLO}$	UVLO input leakage current	$0V \leq V_{UVLO} \leq 40V$	-1	0	1	$\mu A$
<b>OVERVOLTAGE PROTECTION (OVP) INPUT</b>						
$V_{OVPR}$	OVP threshold voltage, rising		1.18	1.23	1.28	V
$V_{OVPF}$	OVP threshold voltage, falling		1.10	1.17	1.25	V
$I_{OVP}$	OVP input leakage current	$0V \leq V_{OVP} \leq 4V$	-1	0	1	$\mu A$
<b>Current Limit Programming ILIM</b>						
IOL	Overload current limit	$R_{ILIM} = 75k\Omega$ , $V_{IN} - V_{OUT} = 1V$	0.58	0.6	0.72	A
		$R_{ILIM} = 24k\Omega$ , $V_{IN} - V_{OUT} = 1V$	1.6	1.80	2.20	A
		$R_{ILIM} = 8.2k\Omega$ , $V_{IN} - V_{OUT} = 1V$	4.25	4.45	4.70	A
		$R_{ILIM} = 6.8k\Omega$ , $V_{IN} - V_{OUT} = 1V$	5.20	5.35	5.50	A
$I_{FASTTRIP}$	Fast-trip comparator threshold	$6.2k\Omega \leq R_{LIM} \leq 75k\Omega$	1.5*IOL			A
$I_{SCP}$	Short circuit protect current		45			A
<b>BGATE (Blocking FET Gate Driver)</b>						
$V_{BGATE}$	BGATE clamp voltage	$V_{BGATE} - V_{IN\_SYS}$	8.0	10.0	14.0	V
$I_{BGATE}$	Blocking FET gate drive current	$V_{BGATE} - V_{IN\_SYS} = 1V$	16	20	23	$\mu A$
$R_{PD\_BGATE}$	BGATE pull down resistance		800	1300	1500	KΩ
$V_{DRV\_OH}$	DRV logic high level	$V_{DRV} - V_{IN\_SYS}$ , $C_{DRV} \leq 50pF$	3	5	6	V
<b>PASS FET OUTPUT (OUT)</b>						
$R_{ON}$	IN to OUT total ON resistance	$0.6A \leq I_{OUT} \leq 5A$	20	30	50	mΩ
$I_{kgOUT}$	OUT leakage during input supply brownout	$V_{IN\_SYS} = 0V$ , $V_{OUT} = 24V$ , $V_{IN} =$ Floating, $V_{SHDN} = 3V$ , Sinking	3	3.5	7	mA
$V_{REVTH}$	$V_{IN\_SYS} - V_{OUT}$ threshold for reverse protection comparator, rising		-20	-15	-9	mV
$V_{FWDTH}$	$V_{IN\_SYS} - V_{OUT}$ threshold for reverse protection comparator, falling		45	57	67	mV
<b>OUTPUT RAMP CONTROL (dVdT)</b>						
$I_{dVdT}$	dVdT charging current	$V_{dVdT} = 0V$	1.5	2.1	2.5	$\mu A$
$GAIN_{dVdT}$	dVdT to OUT gain	$V_{OUT} / V_{dVdT}$	23.5	25	26	V/V

$V_{dVdTmax}$	dVdT maximum capacitor voltage		4.5	5.0	5.5	V
$R_{dVdT}$	dVdT discharging resistance		10	14.0	24.0	Ω
<b>LOW IQ SHUTDOWN (<math>\overline{SHDN}</math>) INPUT</b>						
$V_{\overline{SHDN}}$	Open circuit voltage	$I_{\overline{SHDN}} = 0.1\mu A$	2.48	2.7	3.3	V
$V_{\overline{SHDNF}}$	$\overline{SHDN}$ threshold voltage for low IQ shutdown, falling		0.8			V
$V_{\overline{SHDNR}}$	$\overline{SHDN}$ threshold rising				2	V
$I_{\overline{SHDN}}$	Leakage current	$V_{\overline{SHDN}} = 0V$	-10	-2.7	0	μA
<b>CURRENT MONITOR OUTPUT (IMON)</b>						
$GAIN_{IMON}$	Gain factor IMON: IOUT	$0.6A \leq I_{OUT} \leq 2A$	25.66	27.9	30.14	μA/A
		$2A \leq I_{OUT} \leq 5A$	26.22	27.9	29.58	μA/A
<b>FAULT FLAG (<math>\overline{FLT}</math>): ACTIVE LOW</b>						
$R_{\overline{FLT}}$	$\overline{FLT}$ Pull-down resistance		50	80	140	Ω
$I_{\overline{FLT}}$	$\overline{FLT}$ Input leakage current	$0V \leq V_{\overline{FLT}} \leq 40V$	-1	0	1	μA
<b>POWER GOOD (PGOOD)</b>						
$R_{PGOOD}$	PGOOD Pull-down resistance		50	80	140	Ω
$I_{PGOOD}$	PGOOD Input leakage current	$0V \leq V_{PGOOD} \leq 40V$	-1	0	1	μA
<b>POSITIVE INPUT FOR POWER GOOD COMPARATOR (PGTH)</b>						
$V_{PGTHR}$	PGTH threshold voltage, rising		1.18	1.24	1.28	V
$V_{PGTHF}$	PGTH threshold voltage, falling		1.10	1.15	1.25	V
$I_{PGTH}$	PGTH input leakage current	$0V \leq V_{PGTH} \leq 40V$	-1	0	1	μA
<b>THERMAL PROTECTION</b>						
$T_{TSDrelease}$	Thermal shutdown release			130		°C
$T_{TSD}$	Thermal shutdown TSD threshold, rising			140		°C
$T_{TSDhyst}$	TSD hysteresis			11		°C

## Timing Requirements

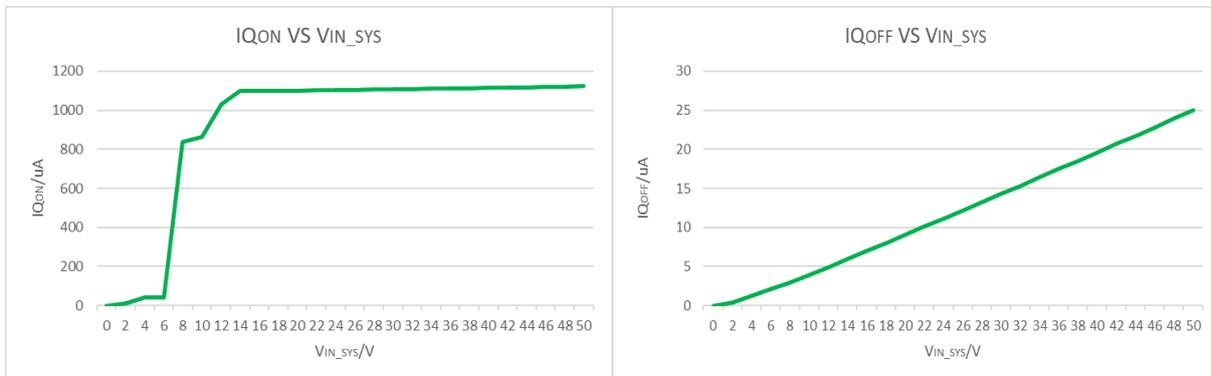
$4.5V \leq V_{IN} \leq 40V$ ,  $V_{SHDN} = 3V$ ,  $R_{ILIM} = 10k\Omega$ ,  $UVLO = OVP = 0V$ ,  $C_{OUT} = 1 \mu F$ ,  $C_{dVdT}$  OPEN. (Unless otherwise noted))

Symbol	Parameter	Test condition	Min	Typ.	Max	Unit
<b>UVLO INPUT (UVLO)</b>						
$UVLO_{ton(dly)}$	UVLO switch turn-on delay	UVLO $\uparrow$ (100mV above $V_{UVLOR}$ ) to $V_{OUT} = 100mV$ with $V_{PGTH} < V_{PGTHF}$ , $C_{dVdT} \geq 10nF$ , [ $C_{dVdT}$ in nF]	$730 + 49.5 \times C_{dVdT}$			$\mu s$
$UVLO_{ton(fast\_dly)}$	UVLO switch turn-on delay (fast)	UVLO $\uparrow$ (100mV above $V_{UVLOR}$ to FET ON with $V_{PGTH} > V_{PGTHF}$ )	70	90	200	$\mu s$
$UVLO_{toff(dly)}$	UVLO switch turnoff delay	UVLO $\downarrow$ (20mV below $V_{UVLOF}$ ) to $\overline{FLT} \downarrow$		520	600	$\mu s$
$t_{UVLO(\overline{FLT}dly)}$	UVLO to fault de-assertion delay	UVLO $\uparrow$ to $\overline{FLT} \uparrow$ delay	500	640	700	$\mu s$
<b>OVER VOLTAGE PROTECTION INPUT (OVP)</b>						
$OVP_{toff(dly)}$	OVP switch turnoff delay	OVP $\uparrow$ (20mV above $V_{OVPR}$ ) to $\overline{FLT} \downarrow$	8	14	30	$\mu s$
$OVP_{ton(fast\_dly)}$	OVP switch turn-on delay (fast)	OVP $\downarrow$ (100mV below $V_{OVPF}$ ) to FET ON with $V_{PGTH} > V_{PGTHF}$	10	34	60	$\mu s$
$OVP_{ton(dly)}$	OVP switch disable delay	OVP $\downarrow$ (100mV below $V_{OVPF}$ ) to FET ON with $V_{PGTH} < V_{PGTHF}$ , $C_{dVdT} \geq 10nF$ , [ $C_{dVdT}$ in nF]	$200 + 49.5 \times C_{dVdT}$			$\mu s$
<b>SHUTDOWN CONTROL INPUT (<math>\overline{SHDN}</math>)</b>						
$t_{SD(dly)}$	SHUTDOWN entry delay	$\overline{SHDN} \downarrow$ (below $V_{SHUTE}$ ) to FET OFF	0.8	1	1.5	$\mu s$
<b>CURRENT LIMIT</b>						
$t_{FASTTRIP(dly)}$	Hot-short response time	$I_{OUT} > I_{SCP}$		1		$\mu s$
	Soft short response	$I_{FASTTRIP} < I_{OUT} < I_{SCP}$	2.2	3.2	4.5	$\mu s$
$t_{CBRetry(dly)}$	Retry delay in Pulse over current limiting		550	670	800	ms
<b>REVERSE CURRENT BLOCKING (RCB) COMPARATOR</b>						
$t_{RCB(fast\_dly)}$	Reverse protection comparator detection delay (reverse)	$(V_{IN\_SYS} - V_{OUT}) \downarrow$ (1V overdrive below $V_{REVTH}$ ) to $V_{DRV} - V_{IN\_SYS} = V_{DRV\_OH}$		0.2		$\mu s$
$t_{RCB(dly)}$		$(V_{IN\_SYS} - V_{OUT}) \downarrow$ (10mV overdrive below $V_{REVTH}$ ) to $V_{DRV} - V_{IN\_SYS} = V_{DRV\_OH}$		0.5		$\mu s$
$t_{RCB(flt\_dly)}$	Fault assertion Delay	$(V_{IN\_SYS} - V_{OUT}) \downarrow$ (10mV overdrive below $V_{REVTH}$ ) to $\overline{FLT} \downarrow$	500	600	800	$\mu s$
$t_{FWD\_FLT(dly)}$	Reverse protection comparator detection delay (forward)	$(V_{IN\_SYS} - V_{OUT}) \uparrow$ (10mV overdrive above $V_{FWDTH}$ ) to $V_{BGATE} - V_{IN\_SYS} = 5V$ , $C_{BFET-IN\_SYS} = 4.7nF$		1.0		ms
	Fault de-assertion Delay	$(V_{IN\_SYS} - V_{OUT}) \uparrow$ (10mV overdrive above $V_{FWDTH}$ ) to $\overline{FLT} \uparrow$	430	630	800	$\mu s$
<b>OUTPUT RAMP CONTROL (dVdT)</b>						

$t_{\text{FASTCHARGE}}$	Output ramp time in fast charging	$C_{\text{dVdT}} = \text{Open}$ , 10% to 90% $V_{\text{OUT}}$ , $C_{\text{OUT}} = 1\mu\text{F}$ ; $V_{\text{IN}} = 24\text{V}$	50	100	300	$\mu\text{s}$
$t_{\text{dVdT}}$	Output ramp time	$C_{\text{dVdT}} = 10\text{nF}$ , 10% to 90% $V_{\text{OUT}}$ , $V_{\text{IN}} = 24\text{V}$		4.0		ms
<b>POWER GOOD (PGOOD)</b>						
$t_{\text{PGOODR}}$	PGOOD delay (deglitch) time	Rising edge	1.0	2.0	3.0	ms
$t_{\text{PGOODF}}$	PGOOD delay (deglitch) time	Falling edge, $\text{PGTH} \downarrow$ (10mV below $V_{\text{PGTHF}}$ )	1.3	3.2	4	$\mu\text{s}$
<b>FAULT FLAG (<math>\overline{\text{FLT}}</math>)</b>						
$t_{\text{CB\_FLT}} (\text{dly})$	$\overline{\text{FLT}}$ assertion delay in Pulse over current limiting	Delay from $I_{\text{OUT}} > I_{\text{OL}}$ to $\overline{\text{FLT}} \downarrow$ .	22	25	30	ms
<b>THERMAL PROTECTION</b>						
$t_{\text{TSD\_retry}}$	Retry delay in TSD		500	660	800	ms

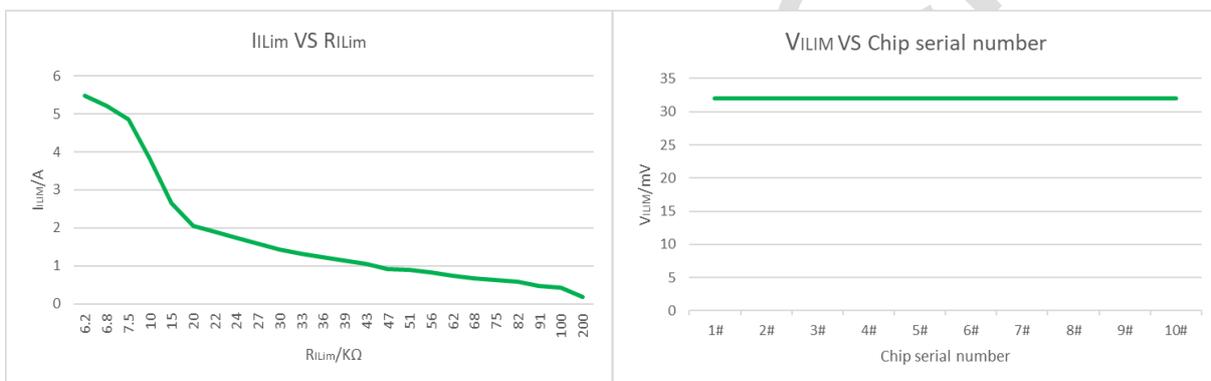
### Typical Characteristics

$V_{IN\_SYS} = V_{IN} = 24V$ ,  $V_{SHDN} = 3V$ ,  $R_{ILIM} = 10k\Omega$ ,  $UVLO = OVP = 0V$ ,  $C_{OUT} = 1\mu F$ ,  $C_{VAT} = OPEN$ . (Unless stated otherwise)



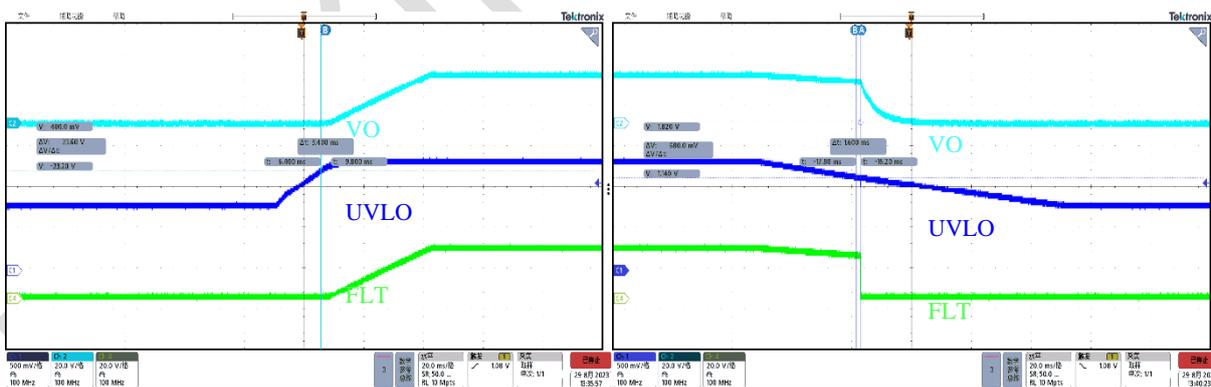
Supply Current vs Supply Voltage During Normal Operation

Supply Current vs Supply Voltage in Shutdown



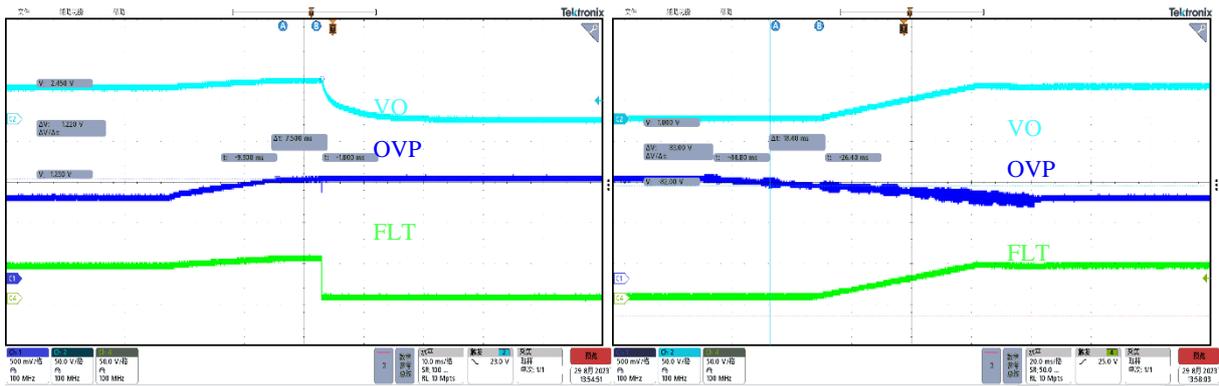
IILIM VS RILIM with  $V_{IN\_SYS} = 24V$

VILIM consistency between different chips



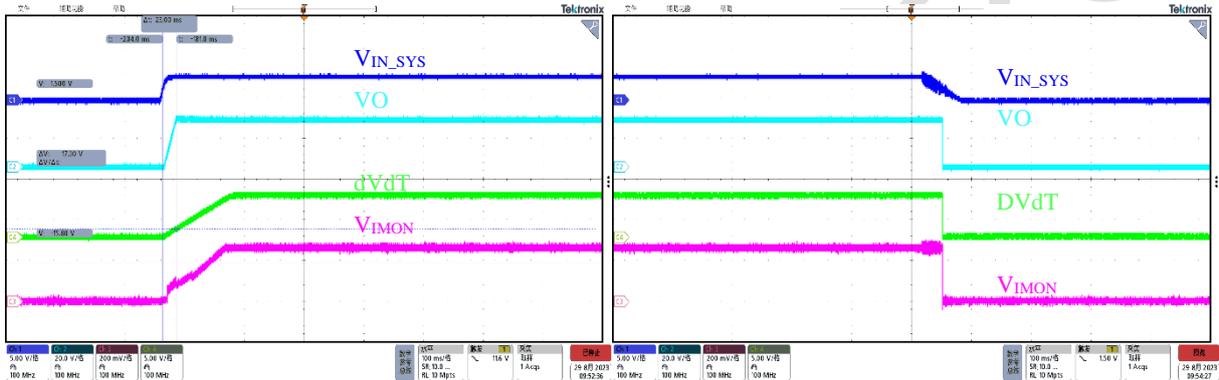
UVLO Performance during  $V_{IN\_SYS}$  from 14V to 24V

UVLO Performance during  $V_{IN\_SYS}$  from 24V to 14V



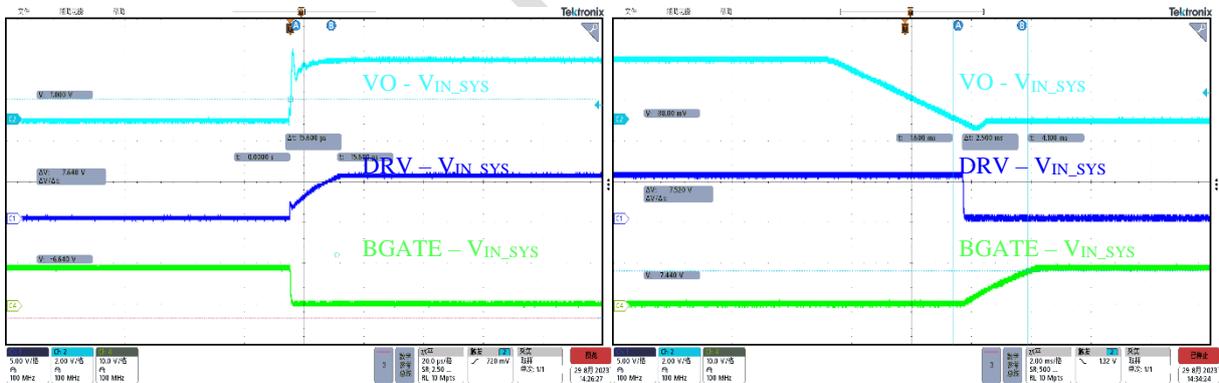
Enter OVP protection

Exit OVP Protection



Turn on control with SHDN

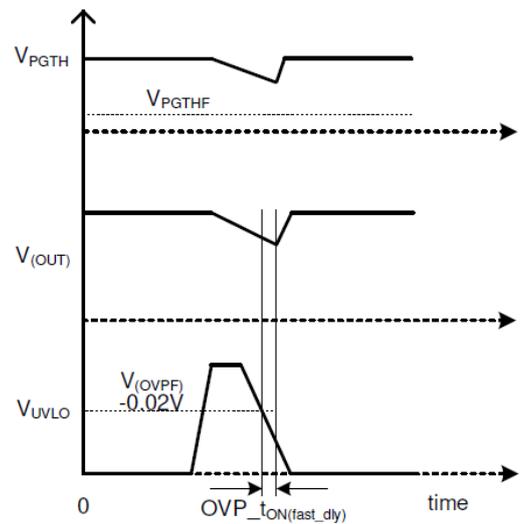
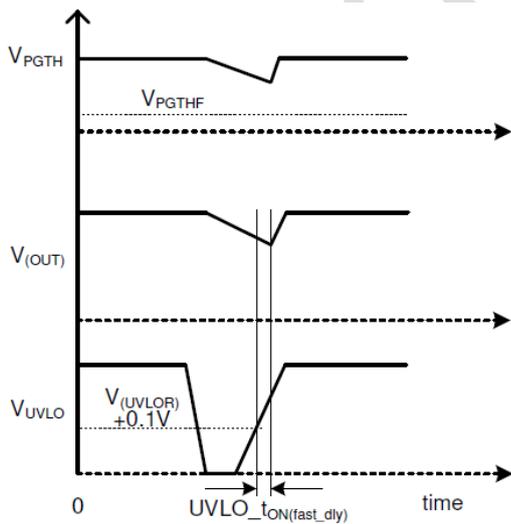
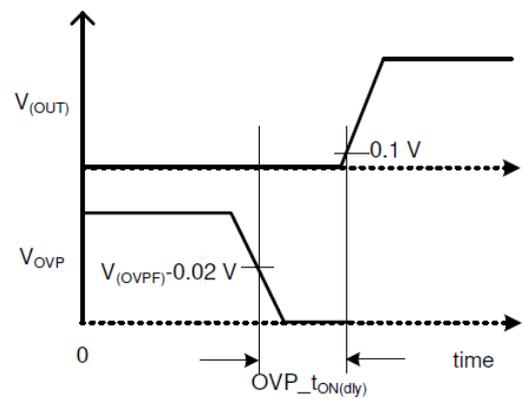
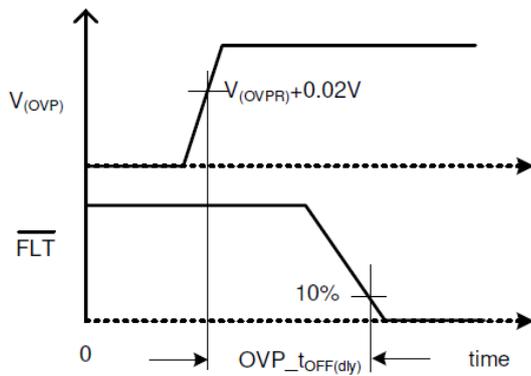
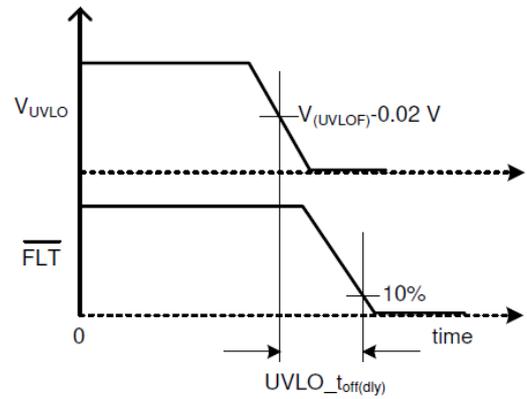
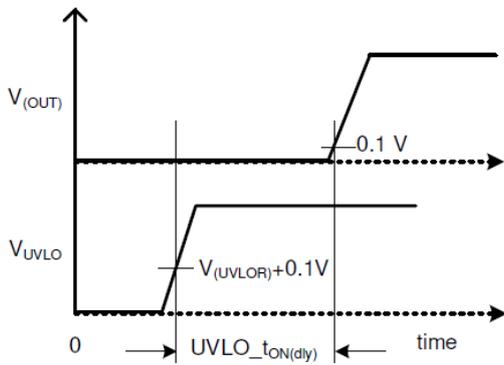
Turn off control with SHDN

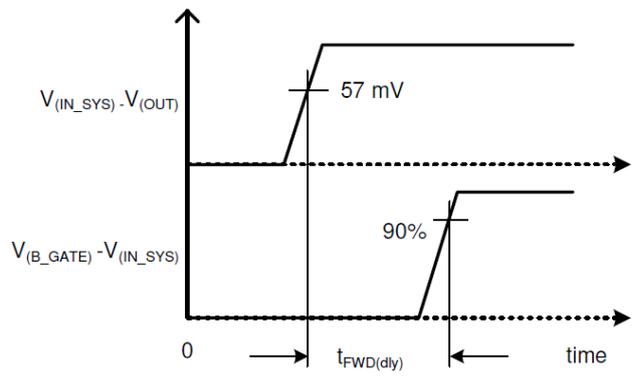
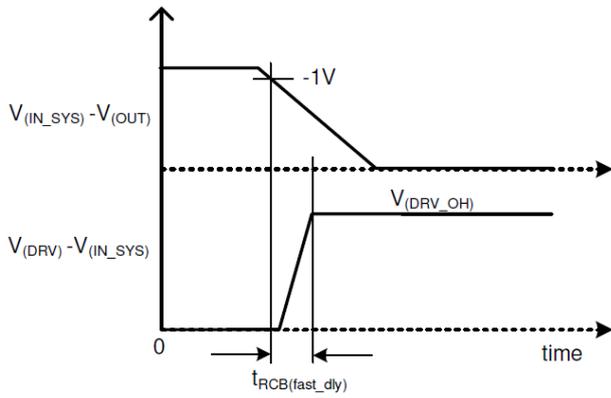


Enter Reverse Current Protection

Exit Reverse Current Protection

## Parameter Measurement Information





MAXIN MICRO

## Operation description

The MX26631DL is an 40V industrial eFuse. The device provides robust protection for all systems and applications powered from 4.5V to 40V. For hot-pluggable boards, the devices provide hot-swap power management with in-rush current control and programmable output voltage slew rate features using the dVdT pin. Load, source, and device protections are provided with many programmable features including overcurrent, overvoltage and undervoltage. The precision overcurrent limit ( $\pm 10\%$  at 5A) helps to minimize over design of the input power supply, while the fast response short circuit protection immediately isolates the faulty load from the input supply when a short circuit is detected. The device features fast reverse current blocking response (0.2us). The internal robust protection control blocks of the MX26631DL along with its 40V rating, helps to simplify the system designs for the industrial surge compliance ensuring complete protection of the load and the device. The 40V maximum DC operating and 60V absolute maximum voltage rating enables system protection from 40V DC input supply faults and from industrial SELV power supplies.

By monitoring the output (Load) voltage through the PGTH pin, the device distinguishes between real system faults and system transients and the turn ON delay during a fault recovery is controlled accordingly. The valid load voltage detection threshold can be adjusted using a resistor ladder network from OUT, PGTH and GND.

The devices provide precise monitoring of voltage bus for brown-out, overvoltage conditions and asserts fault signal for the downstream system. Its overall threshold accuracy of 2% ensures tight supervision of bus, eliminating the need for a separate supply voltage supervisor chip. The devices monitor  $V_{IN\_SYS}$  and  $V_{OUT}$  to provide true reverse current blocking when a reverse condition or input power failure condition is detected.

Additional features of the MX26631DL include:

- $\pm 10\%$  Current monitor output ( $I_{MON}$ ) for health monitoring of the system
- PGOOD indicator output with  $\pm 5\%$  accurate adjustable valid load voltage detection threshold (PGTH)
- Over temperature protection to safely shutdown in the event of an overcurrent event

- De-glitched fault reporting for supply brown-out and overvoltage faults

- Enable and disable control from an MCU using  $\overline{SHDN}$  pin.

### Hot Plug-In and In-Rush Current Control

The devices are designed to control the inrush current upon insertion of a card into a live backplane or other "hot" power source. This limits the voltage sag on the backplane's supply voltage and prevents unintended resets of the system power. The controlled start-up also helps to eliminate conductive and radiative interferences. An external capacitor connected from the dVdT pin to GND defines the slew rate of the output voltage at power-on. The fastest output slew rate of 24V/120 $\mu$ s can be achieved by leaving dVdT pin floating. The inrush current can be calculated using the following formula:

$$I = C * \frac{dV}{dT} \geq I_{INRUSH} = C_{OUT} * \frac{V_{IN}}{t_{SST}}$$

where

$$t_{SST} = 20.8 * 10^3 * V_{IN} * C_{dVdT}$$

$t_{SST}$  is the output ramp up time.

### PGOOD and PGTH

The devices feature an open drain Power good (PGOOD) indicator output. PGOOD can be used for enabling and disabling of the downstream loads like DC-DC converters. Connect a resistor ladder network from  $V_{OUT}$ , PGTH and GND to set the PGOOD threshold level. PGOOD goes high when the internal FET's gate is enhanced and  $V_{PGTH}$  is above  $V_{PGTHR}$ . PGOOD goes low when  $V_{PGTH}$  goes below  $V_{PGTHF}$ . There is a deglitch of  $t_{PGOODR}$ , 2.0ms (typical) at the rising edge and  $t_{PGOODF}$ , 3.2 $\mu$ s (typical) deglitch on the falling edge of PGOOD indication. PGOOD is a rated for 40V and can be pulled to  $IN\_SYS$  or OUT through a resistor. PGTH can be used for setting down stream's supply UVLO levels and PGOOD as enable and disable control.

### PGTH as $V_{OUT}$ Sensing Input

The devices use PGTH as the output (Load) voltage monitor input and to set the downstream loads UVLO threshold. To set the input PGTH threshold, connect a resistor divider network from  $V_{OUT}$  to PGTH terminal to GND as shown in the Simplified schematic. During a system fault recovery (example: OVP high to low or UVLO low to high) when the internal FET gate control is enabled, the device samples the PGTH information and decides whether to turn ON the FET

## 40V, 5A, 30mΩ Hot-Swap eFuse Solution

with fast slew rate or dVdT mode based on the sampled  $V_{PGTH}$  information.

During the fault recovery instance if the  $V_{PGTH}$  level is above  $V_{PGTHF}$  then the internal FET turns ON within a delay of  $t_{OVP(dly\_fast)}$  with fast slew rate (ignores the capacitance connected at dVdT pin). Maximum current through the device during this operation is limited at  $I_{OL}$ . During the fault recovery instance if the  $V_{PGTH}$  level is below  $V_{PGTHF}$  then the device turns ON the internal FET in dVdT mode and the slew rate will depend on the dVdT capacitor value and maximum current through the devices is limited at  $I_{OL}$ . This way the device distinguishes between real system faults and system transients and the turn ON delay is controlled accordingly. The fast turn ON during transient recovery feature can be disabled by connecting PGTH to GND. In this case, PGOOD will be pulled low.

### Undervoltage Lockout (UVLO)

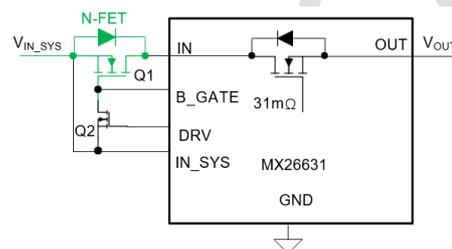
The MX26631DL features an accurate  $\pm 5\%$  adjustable undervoltage lockout functionality. When the voltage at UVLO pin falls below  $V_{UVLOF}$  during input undervoltage fault, the internal FET quickly turns off and  $\overline{FLT}$  is asserted. The UVLO comparator has a hysteresis of 78mV (typical). To set the input UVLO threshold, connect a resistor divider network from IN supply to UVLO terminal to GND as shown in the Simplified schematic. The MX26631DL also features a factory set 15V input supply undervoltage lockout  $V_{IN\_SYS\_UVLO}$  threshold with 1V hysteresis. This feature can be enabled by connecting the UVLO terminal directly to the GND terminal. If the Undervoltage Lock-Out function is not needed, the UVLO terminal must be connected to the IN\_SYS terminal. UVLO terminal must not be left floating. In the applications where reverse polarity protection is required connect a minimum of 300kΩ resistor between UVLO and IN\_SYS.

### Overvoltage Protection (OVP)

The MX26631DL incorporate circuitry to protect the system during overvoltage conditions. The MX26631DL features an accurate  $\pm 5\%$  adjustable overvoltage cut off functionality. A voltage more than  $V_{OVPR}$  on OVP pin turns off the internal FET and protects the downstream load. To program the OVP threshold externally, connect a resistor divider from IN\_SYS supply to OVP terminal to GND as shown in the Simplified schematic.

### Reverse Current Protection

Connect an N-channel power FET (Q1) with the source to IN\_SYS, drain to IN and GATE to BGATE as shown in the following figure. This forms a back-to-back FET topology in power path that is required to protect the current reverse. Connect an external signal FET (Q2) across BGATE, DRV and IN\_SYS. Q2 acts as a pull-down gate switch for Q1. In the applications where reverse polarity protection and reverse current blocking is not required then connect IN\_SYS and IN together and leave BGATE and DRV open.



Configuration for Reverse Current Blocking

The device monitors  $V_{IN\_SYS}$  and  $V_{OUT}$  to provide true reverse current blocking when a reverse condition or input power failure condition is detected.

The reverse comparator turns OFF the external blocking FET Q1 quickly as soon as  $V_{IN\_SYS} - V_{OUT}$  falls below  $-1V$ . The total time taken to turn OFF the FET Q1 in this condition is  $t_{RCB(fast\_dly)} + t_{Driver}$ . The delay due to the driver stage  $t_{Driver}$  can be calculated using the following formula:

$$t_{Driver} = -RDSON_{Q2} * C_{issQ1} * \ln \left( \frac{VGTH_{Q1}}{V_{BGATE}} \right)$$

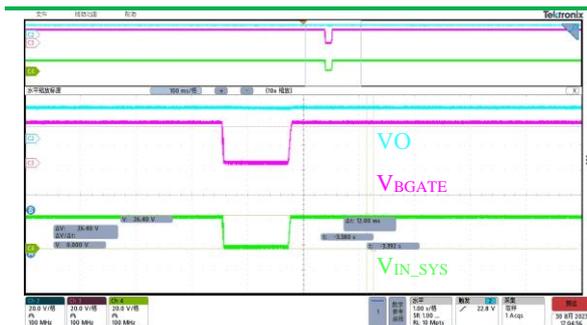
where

- $RDSON_{Q2}$  is the on resistance of the fast pull-down switch Q2
- $C_{issQ1}$  is the input capacitance of the blocking FET Q1
- $VGTH_{Q1}$  is the GATE threshold voltage of the blocking FET Q1
- $V_{BGATE} = 11V$  (typical)

In a typical system design,  $t_{Driver}$  is generally 10% to 20% of  $t_{RCB(fast\_dly)}$  of 0.2μs (typical).

The following figure illustrates the behavior of the system during input hot short circuit condition. The blocking FET Q1 is turned ON within 1.6ms (typical) once the differential forward voltage  $V_{IN\_SYS} - V_{OUT}$  exceeds 57mV (typical).

### 40V, 5A, 30mΩ Hot-Swap eFuse Solution



Input Hot Short Functionality at 24V Supply

The reverse comparator architecture has a supply line noise immunity resulting in a robust performance in noisy environments. This is achieved by controlling the turn OFF time of the internal FET based on the over-drive differential voltage  $V_{IN\_SYS} - V_{OUT}$  over  $V_{REVTH}$ . Higher the over-drive, faster the turn OFF time,  $t_{RCB(dly)}$ .

#### Overload and Short Circuit Protection

The device monitors the load current by sensing the voltage across the internal sense resistor. The FET current is monitored during start-up and normal operation.

#### Overload Protection

Set the current limit using the following formula:

$$I_{OL} = \frac{42}{R_{ILMT}} \times 10^3 (A) \text{ When } 25k \leq R_{ILMT} \leq 75k;$$

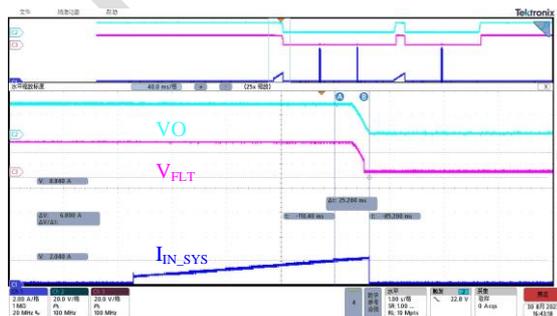
$$I_{OL} = \frac{40}{R_{ILMT}} \times 10^3 (A) \text{ When } 10k < R_{ILMT} < 25k;$$

$$I_{OL} = \frac{37}{R_{ILMT}} \times 10^3 (A) \text{ When } 5.1k \leq R_{ILMT} \leq 10k.$$

Where  $I_{OL}$  is the over current protection point and  $R_{ILMT}$  is the resistor of ILMT pin and the unit is  $\Omega$ .

#### Active Current Limiting with $I_{OL}$ Pulse Current Support

MX26631DL after the start-up and with PGOOD high, if the load current reaches to  $I_{OL}$ , the device will pass through the over current demanded by the load not more than  $I_{OL}$ . Power dissipation across the device during this operation will be  $(V_{IN} - V_{OUT}) \times I_{OL}$  and this could heat up the device and eventually enter thermal shutdown. If load current reaches to  $1.5 \times I_{OL}$ , the internal FET is shut down immediately.

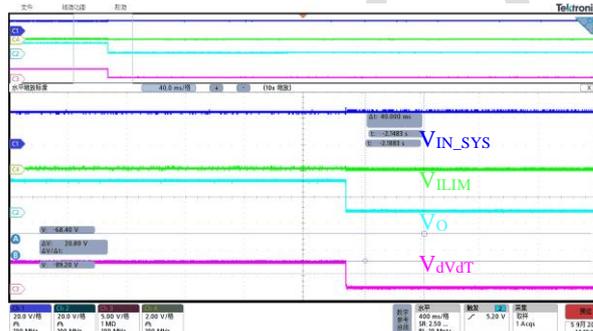


$V_{IN\_SYS} = 24V$   $R_{ILIM} = 20K\Omega$   
Output Hot-Short Response

#### Overload Performance with MX26631DL during Load Step from 0A to 3A

#### MODE

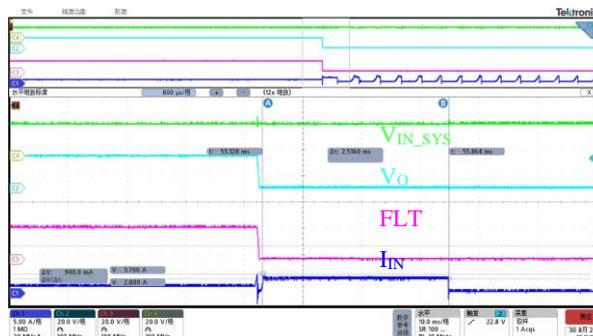
If the voltage of the MODE is less than 1.2V, ILIM pin has short-circuit protection, otherwise the short-circuit protection is in off state. The MX26631DL features open fault detection. When ILIM enters open or short circuit protection, the internal FET is turned OFF and it remains OFF till the ILIM pin fault is removed.



$V_{IN\_SYS} = 24V$ ,  $R_{ILIM} = 6.2k\Omega$  to GND

#### Short Circuit Protection

During a transient output short circuit event, the current through the device increases rapidly. As the current-limit amplifier cannot respond quickly to this event due to its limited bandwidth, the device incorporates a fast-trip comparator. The fast-trip comparator architecture is designed for fast turn OFF during an output short circuit event. The fast-trip threshold is internally set to  $I_{FASTTRIP}$ . The fast trip circuit holds the internal FET off for only a few microseconds, after which the device turns back on slowly, allowing the current-limit loop to regulate the output current to  $I_{OL}$ . Then the device functions is similar to the overload condition. The following figure illustrates output hot-short performance of the device.

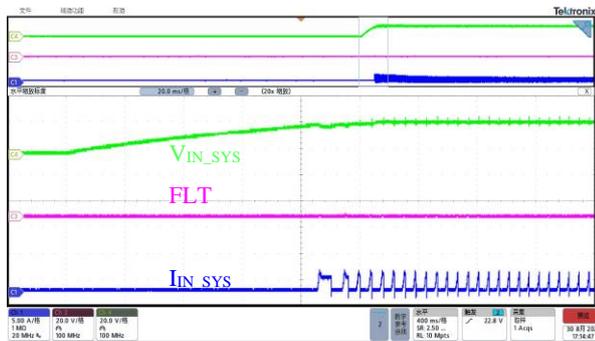


$V_{IN\_SYS} = 24V$   $R_{ILIM} = 20K\Omega$   
Output Hot-Short Response

The fast-trip comparator architecture has a supply line noise immunity resulting in a robust performance in noisy environments. This is achieved by controlling the turn OFF time of the internal FET based on the overcurrent level,  $I_{FASTTRIP}$  through the device. Higher the overcurrent, faster the turn OFF time,  $t_{FASTTRIP(dly)}$ . At overload current level in the range of  $I_{FASTTRIP} < I_{OUT} < I_{SCP}$  the fast-trip comparator response is 3.2μs (typical).

### Start-Up With Short-Circuit on Output

When the device is started with short-circuit on the output, the current begins to limit at  $I_{OL}$ . Due to high power dissipation of  $V_{IN} \times I_{OL}$  within the device the junction temperature increases.  $\overline{FLT}$  remains asserted till the output short-circuit is removed. The following figure illustrates the behavior of the device in this condition.



$V_{IN} = 24V$   $R_{ILIM} = 20k\Omega$

Start-Up With Short on Output

### Current Monitoring Output (IMON)

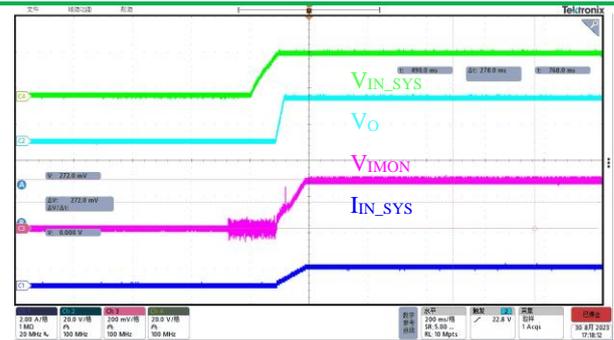
The MX26631DL features an accurate analog current monitoring output. A current source at  $I_{MON}$  terminal is internally configured to be proportional to the current flowing from IN to OUT. This current can be converted into a voltage using a resistor  $R_{IMON}$  from  $I_{MON}$  terminal to GND terminal. The  $I_{MON}$  voltage can be used as a means of monitoring current flow through the system. The maximum voltage  $V_{IMONmax}$  for monitoring the current is limited to 4V. This puts a limitation on maximum value of  $R_{IMON}$  resistor and is determined by the following formula:

$$V_{IMON} = (I_{OUT} * GAIN_{IMON}) * R_{IMON}$$

where,

- $GAIN_{IMON}$  is the gain factor  $I_{MON}$ :  $I_{OUT} = 27.9 \mu A/A$  (Typical)
- $I_{OUT}$  is the load current

The following figure illustrates  $I_{MON}$  performance.



### $I_{MON}$ Response During a Load Step

The  $I_{MON}$  pin must not have a bypass capacitor to avoid delay in the current monitoring information.

### FAULT Response ( $\overline{FLT}$ )

The  $\overline{FLT}$  open-drain output asserts (active low) under the fault's events such as undervoltage, overvoltage, overload, power limiting, reverse current,  $I_{LIM}$  pin short and thermal shutdown conditions. The device is designed to eliminate false reporting by using an internal "de-glitch" circuit for fault conditions without the need for an external circuitry.  $\overline{FLT}$  can be left open or connected to GND when not used.

### IN\_SYS, IN, OUT and GND Pins

Connect a minimum of 0.1μF capacitor across  $IN\_SYS$  and GND. For systems and applications where reverse polarity protection and/or reverse current blocking feature is required

- Connect a N-channel FET between  $IN\_SYS$  and IN with source of the FET connected to  $IN\_SYS$ , Drain at IN, and GATE to BGATE.
- Connect a N-channel signal FET with GATE to DRV, Drain to BGATE, Source to  $IN\_SYS$ .

If the external N-channel FET is not used, then connect  $IN\_SYS$  and IN together and leave BGATE and DRV pins floating. Do not leave any of the IN and OUT pins unconnected.

### Thermal Shutdown

The device has a built-in overtemperature shutdown circuitry designed to protect the internal FET, if the junction temperature exceeds  $T_{SD}$ , 130°C (typical). After the thermal shutdown event, the device commences an auto-retry cycle of 660ms (typical),  $t_{TSD\_retry}$  after  $T_J < [T_{SD} - 11^\circ C]$ . During the thermal shutdown, the fault pin  $\overline{FLT}$  pulls low to indicate a fault condition.

### Low Current Shutdown Control ( $\overline{\text{SHDN}}$ )

The internal, external FET and hence the load current can be switched off by pulling the  $\overline{\text{SHDN}}$  pin below 0.8V threshold with a micro-controller GPIO pin or can be controlled remotely with an opto-isolator device. The device quiescent current reduces to 10 $\mu$ A (typical) in shutdown state. To assert  $\overline{\text{SHDN}}$  low, the pull down must have sinking capability of at least 10 $\mu$ A. To enable the device,  $\overline{\text{SHDN}}$  must be pulled up to at least 2V. Once the device is enabled, the internal FET turns on with dVdT mode.

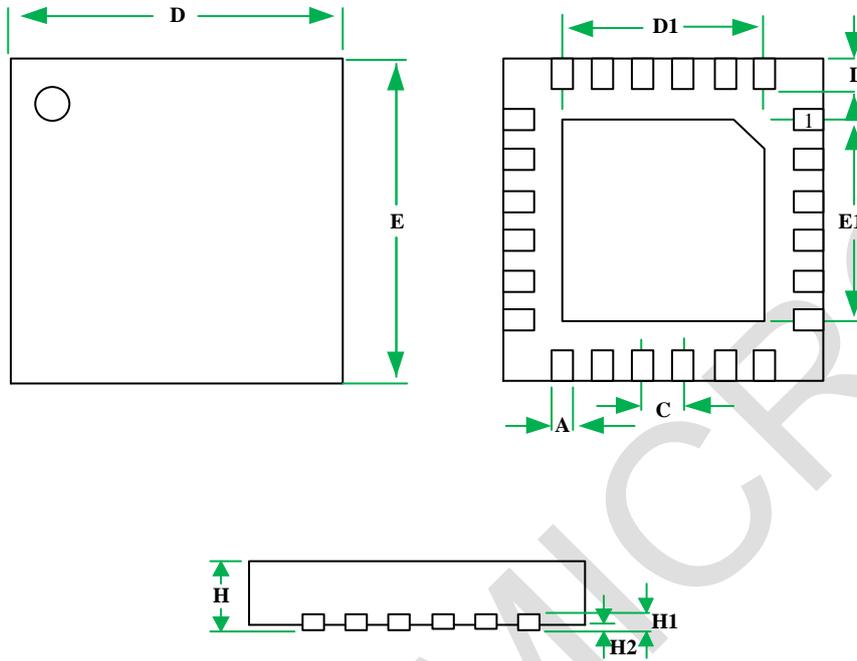
### Layout considerations

- For all the applications, a 0.1 $\mu$ F or higher value ceramic decoupling capacitor is recommended between IN\_SYS terminal and GND.
- The external FET Q1 should be placed with DRAIN close to the VIN pins of MX26631DL and connected through a plane. The fast pulldown switch Q2 DRAIN, and SOURCE should be placed very close to the GATE and SOURCE terminals of Q1 with very short loop.
- The optimum placement of decoupling capacitor is closest to the IN\_SYS and GND terminals of the device. Care must be taken to minimize the loop area formed by the bypass-capacitor connection, the IN\_SYS terminal, and the GND terminal of MX26631DL.
- High current carrying power path connections must be as short as possible and must be sized to carry at least twice the full-load current.
- Locate MX26631DL support components R<sub>LIM</sub>, C<sub>AVdT</sub>, R<sub>IMON</sub>, UVLO, OVP and PGTH resistors close to their connection pin. Connect the other end of the component to the GND with shortest trace length.
- The trace routing for the R<sub>LIM</sub> component to the device must be as short as possible to reduce parasitic effects on the current limit and current monitoring accuracy. These traces must not have any coupling to switching signals on the board.
- Protection devices such as TVS, snubbers, capacitors, or diodes must be placed physically close to the device they are intended to protect and routed with short traces to reduce inductance. For example, a protection Schottky diode is recommended to address negative transients due to switching of inductive loads, and it must be physically close to the OUT

and GND pins.

- Thermal Considerations: When properly mounted, the Power PAD package provides significantly greater cooling ability. To operate at rated power, the Power PAD must be soldered directly to the board GND plane directly under the device. Other planes, such as the bottom side of the circuit board can be used to increase heat sinking in higher current applications.

## Package information



SYMBOL	MILLIMETERS			INCHES		
	MIN	NOM	MAX	MIN	NOM	MAX
A	0.18	0.25	0.30	0.007	0.010	0.012
C		0.50			0.02	
D	3.90	4.00	4.10	0.153	0.157	0.161
E	3.90	4.00	4.10	0.153	0.157	0.161
D1	2.60	2.70	2.80	0.102	0.106	0.110
E1	2.60	2.70	2.80	0.102	0.106	0.110
L	0.35	0.40	0.45	0.014	0.017	0.019
H	0.7	0.75	0.8	0.027	0.029	0.031
H1		0.203			0.008	
H2	0.00	0.025	0.05	0.000	0.001	0.002

QFN4\*4-24L for MX26631DL

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## Restrictions on Product Use

- ◆ MAXIN micro is continually working to improve the quality and reliability of its products. Nevertheless, semiconductor devices in general can malfunction or fail due to their inherent electrical sensitivity and vulnerability to physical stress. It is the responsibility of the buyer, when utilizing MAXIN products, to comply with the standards of safety in making a safe design for the entire system, and to avoid situations in which a malfunction or failure of such MAXIN products could cause loss of human life, bodily injury or damage to property.
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- ◆ The information contained herein is subject to change without notice.

Version update record:

V10 The original version (preliminary)

V11 updated waves and date.

V12 update UL certification