

EVALUATION KIT  
AVAILABLE**MAXIM**

# Low-Cost, High-Reliability, 0.5V to 3.3V ORing MOSFET Controllers

## General Description

Critical loads often employ parallel-connected power supplies with redundancy to enhance system reliability. The MAX8555/MAX8555A are highly integrated, inexpensive MOSFET controllers that provide isolation and redundant power capability in high-reliability systems. The MAX8555/MAX8555A are used in 0.5V to 3.3V systems, and have an internal charge pump to drive the gates of the N-channel pass elements to ( $V_{CS+} + 5V$ ).

During startup, the MAX8555/MAX8555A monitor the voltage drop across the external MOSFETs. Once  $V_{CS+}$  approaches or exceeds the bus voltage ( $V_{CS-}$ ), the MOSFETs are turned on. The MAX8555/MAX8555A feature a dual-purpose TIMER input. A single external resistor from TIMER to ground sets the turn-on speed of the external MOSFETs. Optionally, the TIMER input can be used as a logic enable input. Once the external MOSFET is turned on, these controllers monitor the load, protecting the bus against overvoltage, undervoltage, and reverse-current fault conditions. The MAX8555 is available with a 40mV reverse-current threshold, while the MAX8555A is available with a 20mV reverse-current threshold.

Overvoltage and undervoltage fault thresholds are adjustable and can be disabled. The current-limit trip points are set by the external MOSFETs'  $R_{DS(ON)}$ , reducing component count. An open-drain, logic-low fault output indicates if an overvoltage, undervoltage, or reverse-current fault occurs. The MAX8555 and the MAX8555A can shut down in response to a reverse-current fault condition as quickly as 200ns.

Both devices come in space-saving 10-pin  $\mu$ MAX or TDFN packages and are specified over the extended -40°C to +85°C temperature range.

## Applications

- Point-of-Load Supplies
- Power-Supply Modules
- Servers
- Telecom Power Supplies
- Rectifiers
- Redundant Power Supplies in High-Availability Systems

*Typical Operating Circuit appears at end of data sheet.*

## Features

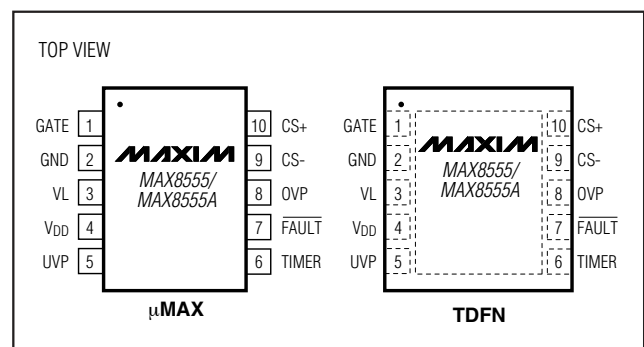
- ◆ Simple, Integrated, and Inexpensive MOSFET Controllers
- ◆ ORing FET Drive for 0.5V to 3.3V
- ◆ Eliminate ORing Diode Power Dissipation
- ◆ Provide N+1 Redundant Supply Capability for Highly Reliable Systems
- ◆ Isolate Failed Short-Circuit Supply from Output BUS
- ◆ Respond to Reverse Short-Circuit Current in 200ns
- ◆ Adjustable Blank Time
- ◆ Programmable Soft-Start
- ◆ Logic Enable Input
- ◆ Adjustable Overvoltage and Undervoltage Trip Points
- ◆ Fault-Indicator Output
- ◆ Space-Saving Packages

## Ordering Information

PART	TEMP RANGE	PIN-PACKAGE	TOP MARK
MAX8555ETB	-40°C to 85°C	10 TDFN 3mm x 3mm*	ACC
MAX8555EUB	-40°C to 85°C	10 $\mu$ MAX	8555EUB
MAX8555AETB	-40°C to 85°C	10 TDFN 3mm x 3mm*	ADD
MAX8555AEUB	-40°C to 85°C	10 $\mu$ MAX	8555AEUB

\*Exposed paddle

## Pin Configurations

**MAXIM**

Maxim Integrated Products 1

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MAX8555/MAX8555A

# Low-Cost, High-Reliability, 0.5V to 3.3V ORing MOSFET Controllers

## ABSOLUTE MAXIMUM RATINGS

GATE to GND .....-0.3V to +12V  
 FAULT, VL to GND .....-0.3V to +6V  
 OVP, UVP, TIMER, CS+, CS- to GND .....-0.3V to +(V<sub>VL</sub> + 0.3V)  
 V<sub>DD</sub> to GND .....(V<sub>VL</sub> - 0.3V) to +18V  
 Continuous Power Dissipation (T<sub>A</sub> = +70°C)  
 10-Pin μMAX (derate 5.6mW/°C above +70°C) .....444mW  
 10-Pin TDFN (derate 24.4mW/°C above +70°C) .....1951mW

Operating Temperature Range .....-40°C to +85°C  
 Junction Temperature .....+150°C  
 Storage Temperature Range .....-65°C to +150°C  
 Lead Temperature (soldering, 10s) .....+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 in the operational sections of the specifications is not implied. Exposure to absolute maximum rating conditions for extended periods may affect device reliability.

## ELECTRICAL CHARACTERISTICS

(V<sub>DD</sub> = 12V, V<sub>CS-</sub> = 1.4V, V<sub>CS+</sub> = 1.5V, R<sub>TIMER</sub> = 25kΩ, V<sub>UVP</sub> = 1V, V<sub>OVP</sub> = 0.25V, R<sub>FAULT</sub> = 50kΩ, C<sub>VDD</sub> = C<sub>GATE</sub> = C<sub>VL</sub> = 0.01μF, T<sub>A</sub> = 0°C to +85°C, unless otherwise noted.)

PARAMETER	CONDITIONS		MIN	TYP	MAX	UNITS
<b>V<sub>DD</sub> SUPPLY</b>						
V <sub>DD</sub> Input Voltage	V <sub>TIMER</sub> = 2.5V	VL unconnected	8.00		13.25	V
		VL = V <sub>DD</sub>	3.0		5.5	
V <sub>DD</sub> Supply Current	VL unconnected, V <sub>TIMER</sub> = 2.5V, V <sub>DD</sub> = 13.25V			2.0	3.3	mA
	V <sub>DD</sub> = V <sub>VL</sub> = 5V, V <sub>TIMER</sub> = 2.5V			0.04	0.2	
V <sub>DD</sub> Shutdown Current	V <sub>TIMER</sub> = 0V, V <sub>DD</sub> = 13.25V				3.0	mA
V <sub>DD</sub> Overvoltage Internal Threshold	Rising threshold		14.0	14.4	15.0	V
	Falling threshold		13.3	13.8	14.5	
<b>VL SUPPLY</b>						
VL Input Voltage	V <sub>DD</sub> = V <sub>VL</sub>		3.0		5.5	V
VL Supply Current	V <sub>DD</sub> = V <sub>VL</sub> = 5V, V <sub>TIMER</sub> = 2.5V			1.8	3.0	mA
VL Current in Shutdown Mode	TIMER = GND, V <sub>DD</sub> = V <sub>VL</sub> = 5V			1.6	3.0	mA
VL Output Voltage	V <sub>DD</sub> = 8V to 13.25V, I <sub>VL</sub> = 0A		3.80	4.1	4.45	V
VL Undervoltage Lockout	VL = V <sub>DD</sub> , rising threshold		2.78	2.82	2.90	V
	VL = V <sub>DD</sub> , falling threshold		2.68	2.75	2.82	
<b>CS INPUTS</b>						
CS+, CS- Input Current	V <sub>TIMER</sub> = 2.5V, V <sub>CS</sub> = 3.0V			5.2		μA
Offset Input Current (CS+, CS-)	V <sub>CS</sub> = 3.0V, Figure 4		-250		+250	nA
CS+/CS- Input Range	(Note 1)		0.5		V <sub>VL</sub> - 0.5	V
CS Isolation	V <sub>CS+</sub> = +3V, V <sub>CS-</sub> = 0V, I <sub>CS-</sub>			-0.5		μA
	V <sub>CS-</sub> = +3V, V <sub>CS+</sub> = 0V, I <sub>CS+</sub>			-0.5		
<b>CHARGE-PUMP VOLTAGE</b>						
GATE Voltage, V <sub>GATE</sub>	Measured from GATE to CS+	V <sub>DD</sub> = 8V to 13.25V	5.0	5.25	5.5	V
		V <sub>DD</sub> = V <sub>VL</sub> = 5V				
Charge-Pump Switching Frequency	R <sub>TIMER</sub> = 20kΩ					kHz
	R <sub>TIMER</sub> = 125kΩ		187			
	R <sub>TIMER</sub> = open		450			
	V <sub>TIMER</sub> = 1.5V		500			
				550		

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MAX8555/MAX8555A

## ELECTRICAL CHARACTERISTICS (continued)

( $V_{DD} = 12V$ ,  $V_{CS-} = 1.4V$ ,  $V_{CS+} = 1.5V$ ,  $R_{TIMER} = 25k\Omega$ ,  $V_{UVP} = 1V$ ,  $V_{OVP} = 0.25V$ ,  $R_{FAULT} = 50k\Omega$ ,  $C_{VDD} = C_{GATE} = C_{VL} = 0.01\mu F$ ,  $T_A = 0^\circ C$  to  $+85^\circ C$ , unless otherwise noted.)

PARAMETER	CONDITIONS	MIN	TYP	MAX	UNITS	
<b>TIMER</b>						
TIMER Voltage		1.22	1.25	1.28	V	
TIMER Maximum Source Current	$V_{TIMER} = 1.0V$	85	100	115	$\mu A$	
TIMER High Input Current	$V_{TIMER} = 1.5V$		10	15	$\mu A$	
TIMER Maximum Frequency Select Voltage Input Range	(Note 1)	1.5		$V_{VL}$	V	
TIMER Logic High, $V_{IH}$	Charge pump enabled	1.0			V	
TIMER Logic Low, $V_{IL}$	Charge pump disabled			0.5	V	
<b>FAULT</b>						
Fault Output Low Voltage	$I_{FAULT} = 10mA$			0.2	V	
Fault Sink Current	$V_{FAULT} = 0.4V$	15			mA	
Fault Leakage Current	$V_{FAULT} = 5.5V$ , $T_A = +25^\circ C$			1	$\mu A$	
<b>GATE</b>						
Gate-On Threshold	Measured from CS- to CS+	MAX8555	80	100	120	mV
		MAX8555A	35	50	65	
Gate-Drive Current	$V_{GATE} = V_{CS+} = 2.5V$	$R_{TIMER} = open$	17	25	33	$\mu A$
		$R_{TIMER} = 25k\Omega$	8	12	16	
	$V_{GATE} = V_{CS+} = 2.5V$ , $V_{DD} = V_{VL} = 3V$	$R_{TIMER} = open$		15		
		$R_{TIMER} = 25k\Omega$		7.5		
	$V_{GATE} = V_{CS+} = 2.5V$ , $V_{DD} = V_{VL} = 5V$	$R_{TIMER} = open$		30		
		$R_{TIMER} = 25k\Omega$		15		
Gate Shutdown Delay	(Note 2)	$V_{TIMER}$ falling		100	200	ns
		$I_{REV}$ fault		60	150	
Gate Discharge Current	$V_{GATE} = V_{CS+} = +5V$		1000		mA	
GATE Fall Time	Gate voltage fall from $\overline{FAULT}$ to $V_{GATE} = V_{CS+}$ , $R1 = 2\Omega$ , Figure 3 or Figure 4		0.2		$\mu s$	
<b>CURRENT SENSE</b>						
Reverse-Current Threshold	Measured from CS- to CS+	MAX8555	34	40	46	mV
		MAX8555A	16	20	24	
Startup $I_{REV}$ Blank Time	TIMER = unconnected		4.1		ms	
Forward-Current Threshold	Measured from CS+ to CS-	6	10	14	mV	

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## ELECTRICAL CHARACTERISTICS (continued)

( $V_{DD} = 12V$ ,  $V_{CS-} = 1.4V$ ,  $V_{CS+} = 1.5V$ ,  $R_{TIMER} = 25k\Omega$ ,  $V_{UVP} = 1V$ ,  $V_{OVP} = 0.25V$ ,  $R_{FAULT} = 50k\Omega$ ,  $C_{VDD} = C_{GATE} = C_{VL} = 0.01\mu F$ ,  $T_A = 0^{\circ}C$  to  $+85^{\circ}C$ , unless otherwise noted.)

PARAMETER	CONDITIONS	MIN	TYP	MAX	UNITS
<b>OVERVOLTAGE PROTECTION</b>					
OVP Fault Threshold, $V_{OVP}$	OVP rising	0.49	0.5	0.51	V
	OVP falling	0.4			
OVP Bias Current	$T_A = +25^{\circ}C$	0.1			$\mu A$
	$T_A = +85^{\circ}C$	0.021			
<b>UNDERVOLTAGE PROTECTION</b>					
UVP Fault Threshold, $V_{UVP}$	UVP rising	0.488	0.5	0.512	V
	UVP falling	0.4			
UVP Bias Current	$T_A = +25^{\circ}C$	0.1			$\mu A$
	$T_A = +85^{\circ}C$	0.003			

## ELECTRICAL CHARACTERISTICS

( $V_{DD} = 12V$ ,  $V_{CS-} = 1.4V$ ,  $V_{CS+} = 1.5V$ ,  $R_{TIMER} = 25k\Omega$ ,  $V_{UVP} = 1V$ ,  $V_{OVP} = 0.25V$ ,  $R_{FAULT} = 50k\Omega$ ,  $C_{VDD} = C_{GATE} = C_{VL} = 0.01\mu F$ ,  $T_A = -40^{\circ}C$  to  $+85^{\circ}C$ , unless otherwise noted.) (Note 3)

PARAMETER	CONDITIONS	MIN	TYP	MAX	UNITS	
<b>V<sub>DD</sub> SUPPLY</b>						
V <sub>DD</sub> Input Voltage	$V_{TIMER} = 2.5V$	VL unconnected	8.00	13.25	V	
		VL = V <sub>DD</sub>	3.0	5.5		
V <sub>DD</sub> Supply Current	VL unconnected, $V_{TIMER} = 2.5V$ , $V_{DD} = 13.25V$			3.3	mA	
	$V_{DD} = V_{VL} = 5V$ , $V_{TIMER} = 2.5V$			0.2		
V <sub>DD</sub> Shutdown Current	$V_{TIMER} = 0V$ , $V_{DD} = 13.25V$			3.0	mA	
V <sub>DD</sub> Overvoltage Internal Threshold	Rising threshold		14.0	15.0	V	
	Falling threshold		13.3	14.5		
<b>VL SUPPLY</b>						
VL Input Voltage	$V_{DD} = V_{VL}$		3.0	5.5	V	
VL Supply Current	$V_{DD} = V_{VL} = 5V$ , $V_{TIMER} = 2.5V$			3.0	mA	
VL Current in Shutdown Mode	TIMER = GND, $V_{DD} = V_{VL} = 5V$			3.0	mA	
VL Output Voltage	$V_{DD} = 8V$ to $13.25V$ , $I_{VL} = 0A$			3.80	4.45	V
VL Undervoltage Lockout	VL = V <sub>DD</sub> , rising threshold		2.78	2.90	V	
	VL = V <sub>DD</sub> , falling threshold		2.68	2.82		
<b>CS INPUTS</b>						
Offset Input Current (CS+, CS-)	$V_{CS} = 3.0V$ , Figure 4		-250	+250	nA	
CS+/CS- Input Range	(Note 1)		0.5	$V_{VL} - 0.5$	V	
<b>CHARGE-PUMP VOLTAGE</b>						
GATE Voltage, $V_{GATE}$	Measured from GATE to CS+	$V_{DD} = 8V$ to $13.25V$		5.0	5.5	V
		$V_{DD} = V_{VL} = 5V$				

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MAX8555/MAX8555A

## ELECTRICAL CHARACTERISTICS (continued)

(V<sub>DD</sub> = 12V, V<sub>CS-</sub> = 1.4V, V<sub>CS+</sub> = 1.5V, R<sub>TIMER</sub> = 25kΩ, V<sub>UVP</sub> = 1V, V<sub>OVP</sub> = 0.25V, R<sub>FAULT</sub> = 50kΩ, C<sub>VDD</sub> = C<sub>GATE</sub> = C<sub>VL</sub> = 0.01μF, T<sub>A</sub> = -40°C to +85°C, unless otherwise noted.) (Note 3)

PARAMETER	CONDITIONS	MIN	TYP	MAX	UNITS
<b>TIMER</b>					
TIMER Voltage		1.22		1.28	V
TIMER Maximum Source Current	V <sub>TIMER</sub> = 1.0V	85		115	μA
TIMER High Input Current	V <sub>TIMER</sub> = 1.5V			15	μA
TIMER Maximum Frequency Select Voltage Input Range	(Note 1)	1.5		V <sub>VL</sub>	V
TIMER Logic High, V <sub>IH</sub>	Charge pump enabled	1.1			V
TIMER Logic Low, V <sub>IL</sub>	Charge pump disabled			0.5	V
<b>FAULT</b>					
Fault Output Low Voltage	I <sub>FAULT</sub> = 10mA			0.2	V
Fault Sink Current	V <sub>FAULT</sub> = 0.4V	15			mA
<b>GATE</b>					
Gate-On Threshold	Measured from CS- to CS+	MAX8555		80	mV
		MAX8555A		35	
Gate-Drive Current	V <sub>GATE</sub> = V <sub>CS+</sub> = 2.5V	R <sub>TIMER</sub> = open		17	μA
		R <sub>TIMER</sub> = 25kΩ		8	
Gate Shutdown Delay		V <sub>TIMER</sub> falling		200	ns
		I <sub>REV</sub> fault		150	
<b>CURRENT SENSE</b>					
Reverse-Current Threshold	Measured from CS- to CS+	MAX8555		34	mV
		MAX8555A		16	
Forward-Current Threshold	Measured from CS+ to CS-	6		14	mV
<b>OVERVOLTAGE PROTECTION</b>					
OVP Fault Threshold, V <sub>OVP</sub>	OVP rising	0.49		0.51	V
<b>UNDERVOLTAGE PROTECTION</b>					
UVP Fault Threshold, V <sub>UVP</sub>	UVP rising	0.488		0.512	V

**Note 1:** Guaranteed by design. Not production tested.

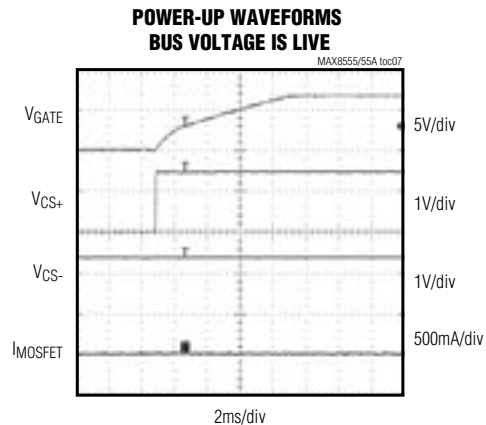
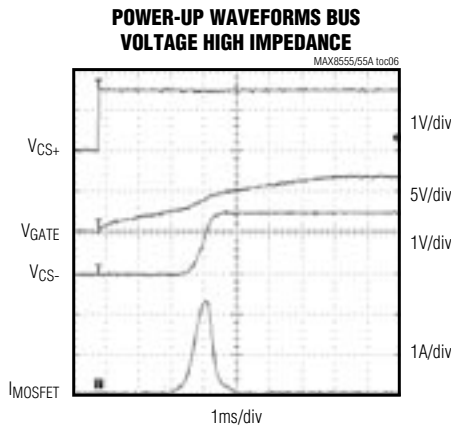
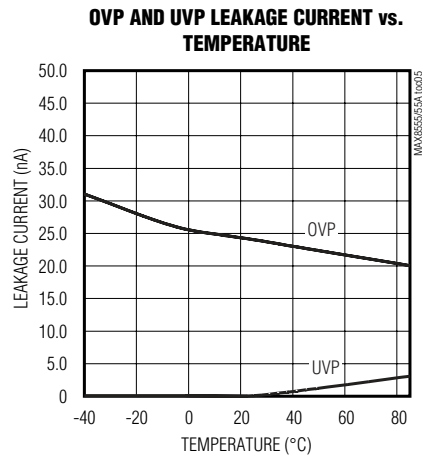
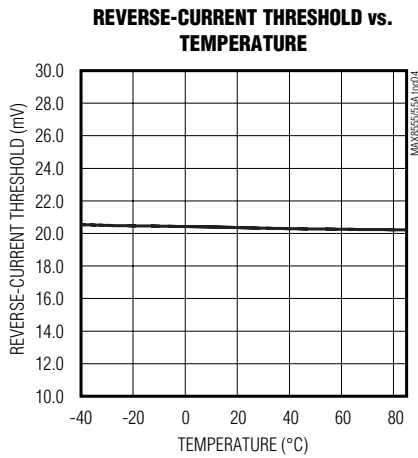
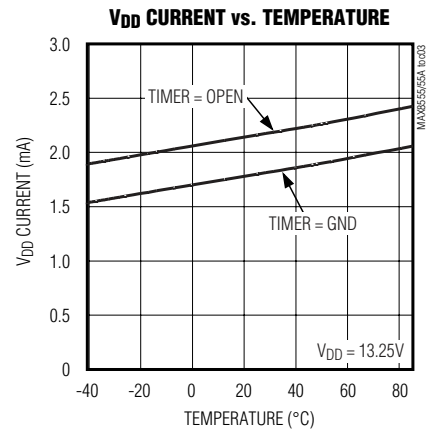
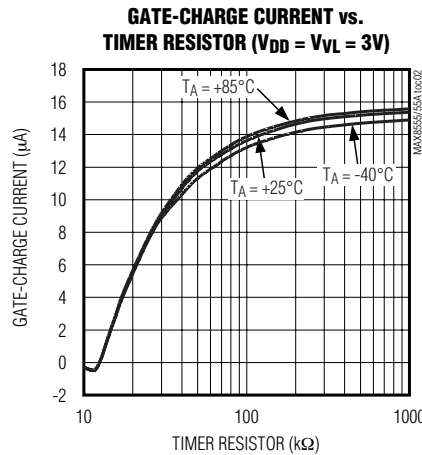
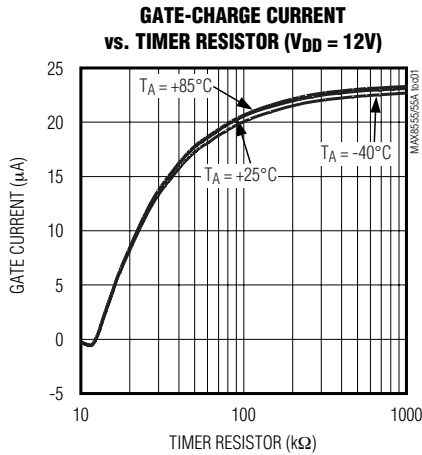
**Note 2:** Gate shutdown delay is measured from reverse-current fault to the start of gate-voltage falling or from TIMER to the start of gate-voltage falling.

**Note 3:** Specifications to -40°C are guaranteed by design and not production tested.

# Low-Cost, High-Reliability, 0.5V to 3.3V ORing MOSFET Controllers

## Typical Operating Characteristics

( $V_{DD} = 12V$ ,  $V_{CS+} = 1.5V$ ,  $R_{TIMER} = 25k\Omega$ ,  $V_{UVP} = 1V$ ,  $V_{OVP} = 0.4V$ ,  $R_{FAULT} = 50k\Omega$  to output bus,  $C_{VDD} = C_{GATE} = C_{VL} = 0.01\mu F$ ,  $T_A = +25^\circ C$ ,  $R_1 = 2\Omega$  in Figure 3, MAX8555A, unless otherwise noted.)



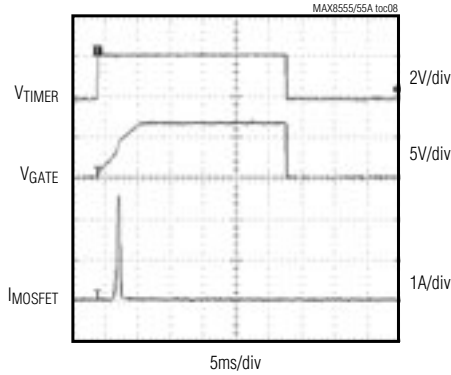
# Low-Cost, High-Reliability, 0.5V to 3.3V ORing MOSFET Controllers

MAX8555/MAX8555A

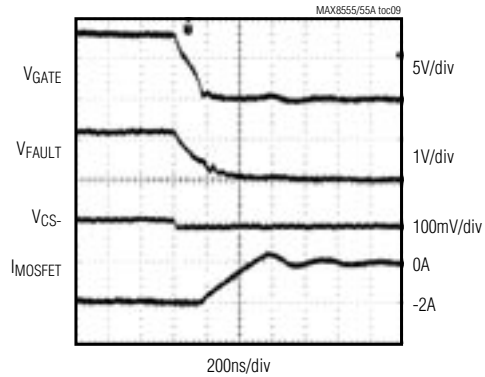
## Typical Operating Characteristics (continued)

( $V_{DD} = 12V$ ,  $V_{CS+} = 1.5V$ ,  $R_{TIMER} = 25k\Omega$ ,  $V_{UVP} = 1V$ ,  $V_{OVP} = 0.4V$ ,  $R_{FAULT} = 50k\Omega$  to output bus,  $C_{VDD} = C_{GATE} = C_{VL} = 0.01\mu F$ ,  $T_A = +25^\circ C$ ,  $R_1 = 2\Omega$  in Figure 3, MAX8555A, unless otherwise noted.)

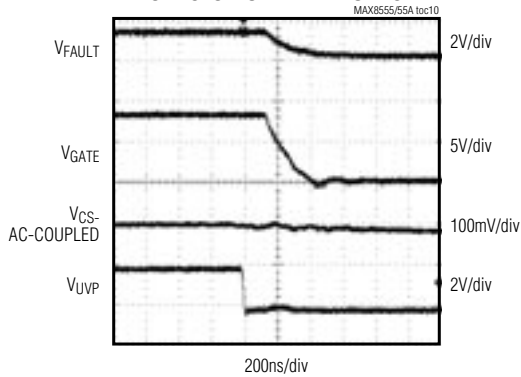
**POWER-UP AND DOWN WAVEFORMS USING TIMER**



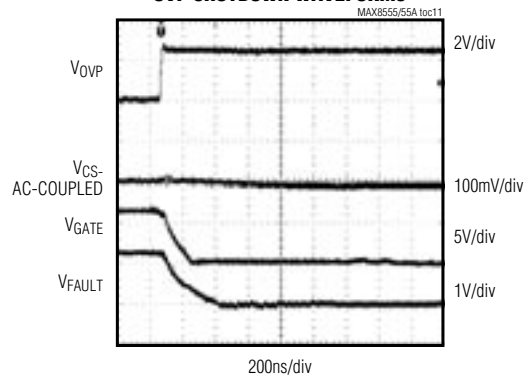
**REVERSE-CURRENT SHUTDOWN WAVEFORMS**



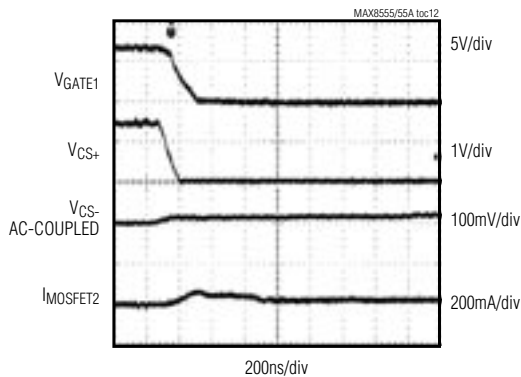
**UVP SHUTDOWN WAVEFORMS**



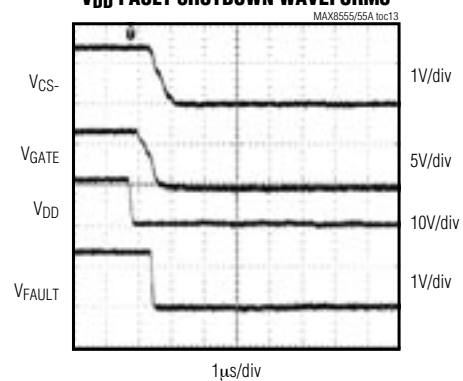
**OVP SHUTDOWN WAVEFORMS**



**POWER-SUPPLY OUTPUT SHORT-CIRCUIT SHUTDOWN WAVEFORMS**



**V<sub>DD</sub> FAULT SHUTDOWN WAVEFORMS**



# Low-Cost, High-Reliability, 0.5V to 3.3V ORing MOSFET Controllers

## Pin Description

PIN	NAME	FUNCTION
1	GATE	Gate-Drive Output. Nominal GATE load is a 0.01 $\mu$ F capacitor to ground. Gate is discharged to GND in shutdown.
2	GND	Ground
3	VL	Low-Voltage Optional Input Power. Leave disconnected when $V_{DD} = 8V$ to 13.25V, or connect $V_{DD}$ to VL when $V_{DD} = 3V$ to 5.5V. Bypass VL to GND with a 0.01 $\mu$ F capacitor.
4	$V_{DD}$	Power-Supply Input. Connect to an 8V to 13.25V supply or connect to VL when using a 3V to 5.5V supply. Bypass $V_{DD}$ with a 0.01 $\mu$ F capacitor to ground.
5	UVP	Undervoltage-Protection Input. Connect UVP to the center of a resistor-divider from CS+ to GND. Connect UVP to VL to disable the undervoltage protection.
6	TIMER	Timer Input. Connect a resistor from TIMER to GND to select the charge-pump operating frequency. Drive TIMER low (< 0.5V) to disable the gate drive. Drive TIMER high (above 1.5V) for charge-pump operation at 550kHz.
7	$\overline{\text{FAULT}}$	Open-Drain Fault Output. $\overline{\text{FAULT}}$ is high impedance during normal operation and is pulled to GND when a fault condition occurs. Connect a pullup resistor of 10k $\Omega$ or higher value (50k $\Omega$ typ) to a voltage rail of 5.5V or lower.
8	OVP	Overvoltage-Protection Input. Connect OVP to the center of a resistor-divider from the output bus to GND. Connect OVP to GND to disable the overvoltage protection.
9	CS-	Current-Sensing Input. Connect CS- to the positive side of the system bus. Bypass with a 1000pF capacitor to GND.
10	CS+	Current-Sensing Input. Connect CS+ to the positive side of the input power. Bypass with a 1000pF capacitor to GND.



# Low-Cost, High-Reliability, 0.5V to 3.3V ORing MOSFET Controllers

MAX8555/MAX8555A

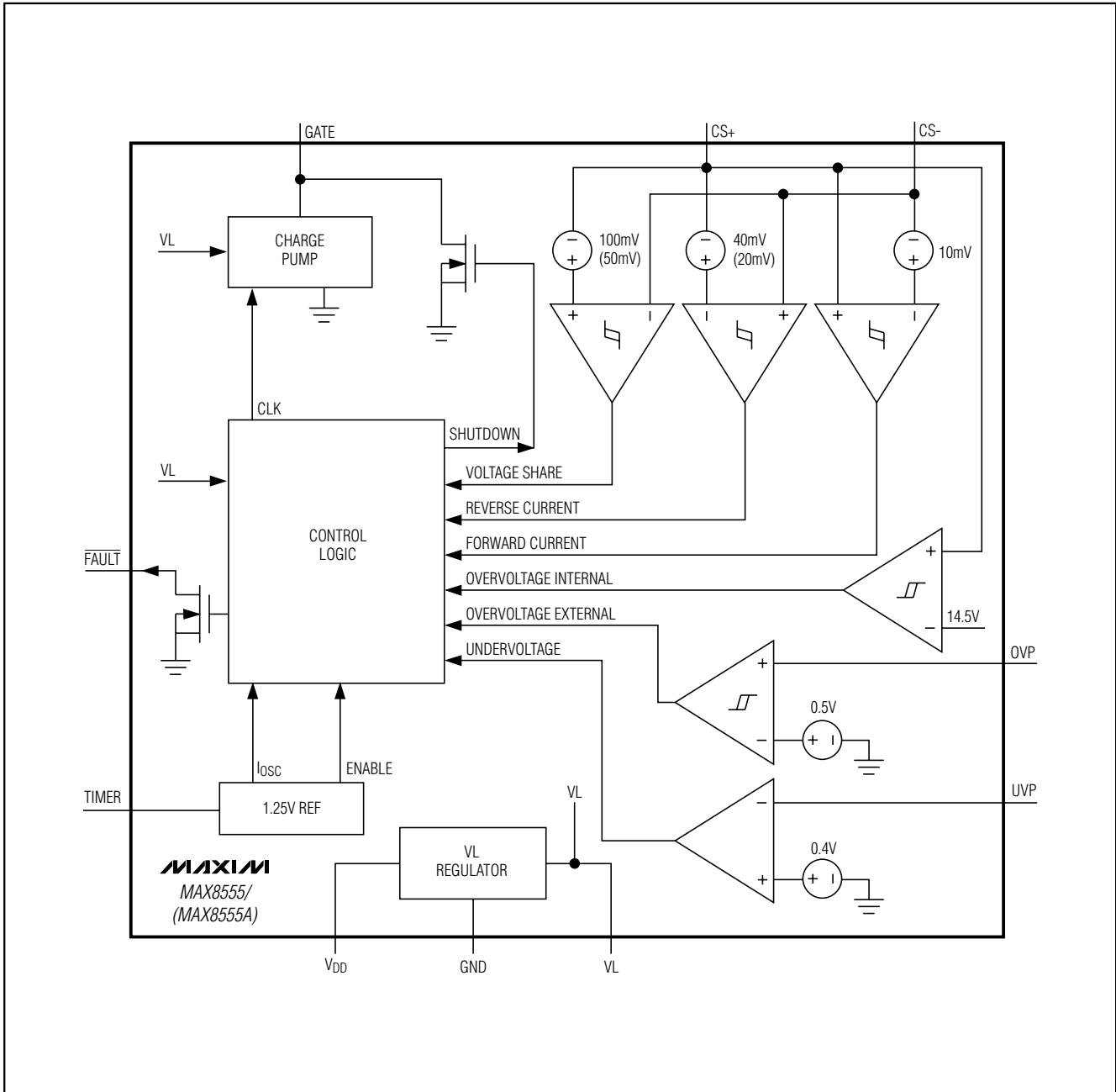
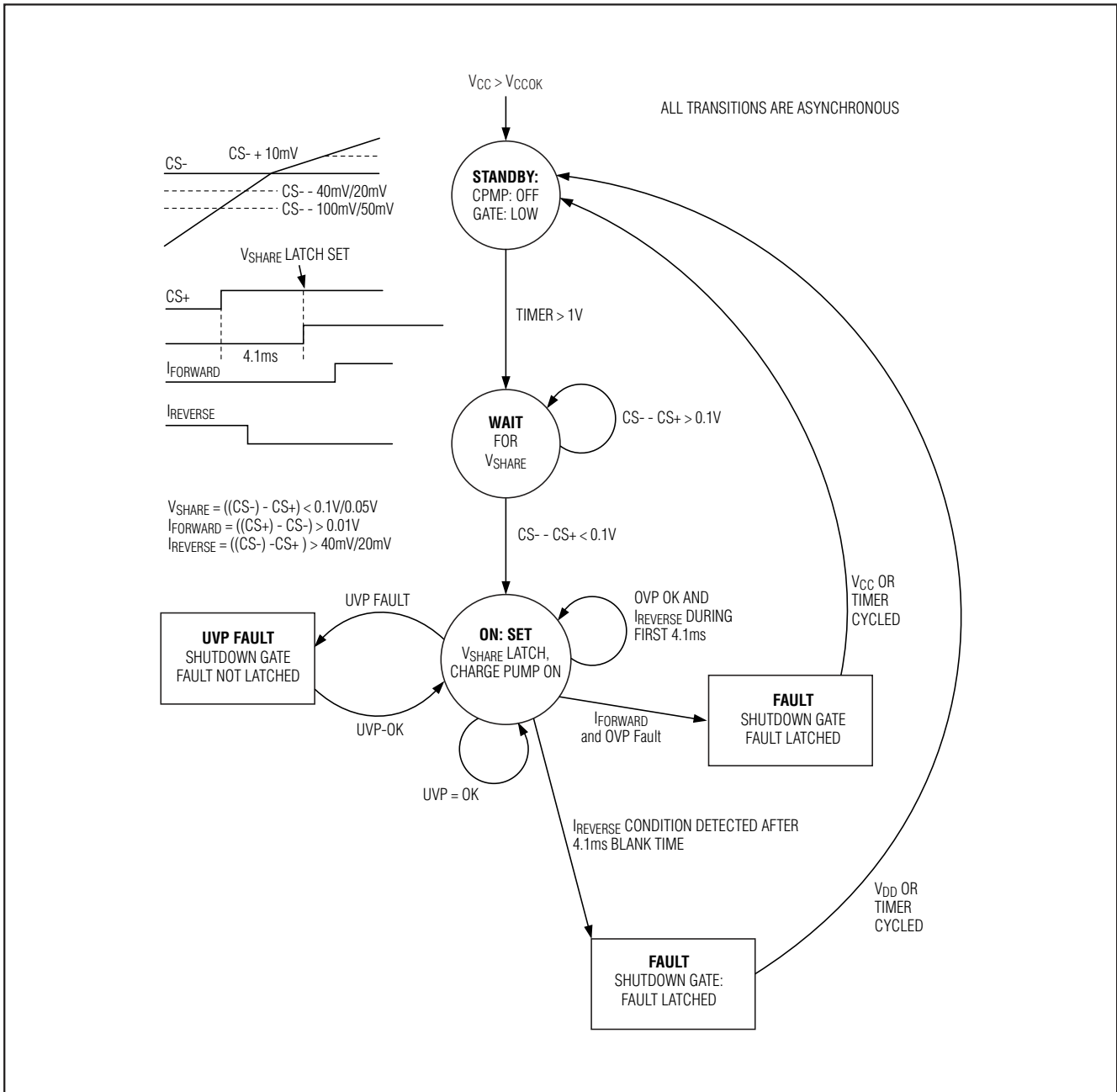


Figure 1. MAX8555/MAX8555A Functional Diagram

# Low-Cost, High-Reliability, 0.5V to 3.3V ORing MOSFET Controllers

## State Diagram



# Low-Cost, High-Reliability, 0.5V to 3.3V ORing MOSFET Controllers

MAX8555/MAX8555A

## General Description

Critical loads often employ parallel-connected power supplies with redundancy to enhance system reliability. The MAX8555/MAX8555A are highly integrated, inexpensive MOSFET controllers that provide isolation and redundant power capability in high-reliability systems. The MAX8555/MAX8555A are used in 0.5V to 3.3V systems, and have an internal charge pump to drive the gates of the N-channel pass elements to  $V_{CS+} + 5V$ .

During startup, the MAX8555/MAX8555A monitor the voltage drop across the external MOSFETs. Once  $V_{CS+}$  approaches or exceeds the bus voltage ( $V_{CS-}$ ), the MOSFETs are turned on. The MAX8555/MAX8555A feature a dual-purpose TIMER input. A single external resistor from TIMER to ground sets the turn-on speed of the external MOSFETs. Optionally, the TIMER input can be used as a logic enable input. Once the external MOSFET is turned on, these controllers monitor the load, protecting the bus against overvoltage, undervoltage, and reverse-current fault conditions. The MAX8555 is available with a 40mV reverse-current threshold, while the MAX8555A is available with a 20mV reverse-current threshold.

Overvoltage and undervoltage fault thresholds are adjustable and can be disabled. The current-limit trip points are set by the external MOSFETs'  $R_{DS(ON)}$ , reducing component count. An open-drain, logic-low fault output indicates if an overvoltage, undervoltage, or reverse-current fault occurs. The MAX8555 and the MAX8555A can shut down in response to a reverse-current fault condition as quickly as 200ns.

## V<sub>DD</sub>

$V_{DD}$  is the power-supply input for the MAX8555/MAX8555A and the input to the internal preregulator. Bypass  $V_{DD}$  to GND with a 0.01 $\mu$ F capacitor. The input supply range for  $V_{DD}$  is 8V to 13.25V. The internal charge pump is disabled for input voltages above 14.4V (typ). For 3V to 5.5V input voltages, connect  $V_{DD}$  to VL.

## VL

VL is the regulated power supply for the MAX8555/MAX8555A. The MAX8555/MAX8555A monitor VL at all times. During startup the device turns on when VL rises above  $V_{LOK}$  (2.82V typ). After  $V_{VL}$  exceeds  $V_{LOK}$  and  $V_{CS+}$  is typically greater than ( $V_{CS-} - 100mV$ ), the charge pump turns on and drives GATE high, turning on the external MOSFETs. For operation from 3V to 5.5V input supplies, connect VL to  $V_{DD}$ .

## TIMER

GATE is the output of the internal charge pump that drives the external MOSFETs. During startup, the voltage at GATE ramps up according to the charge-pump frequency. At 250kHz, the GATE drive current for the MAX8555/MAX8555A is 12 $\mu$ A. Increasing the charge-pump frequency increases the GATE drive current. To change charge-pump frequency, change the value of  $R_{TIMER}$ . See the *Selecting the TIMER Resistor* section.

## CS+, CS-

The voltage drop across the external MOSFETs is measured between the CS+ and CS- inputs. CS+ connects to the positive side of the input voltage. CS- connects to the positive side of the system bus. The MAX8555/MAX8555A use the voltage drop across CS+ and CS- to determine operating mode. I<sub>FORWARD</sub> is defined as  $V_{CS+} - V_{CS-}$  and must be greater than 0.01V (typ) to properly detect an overvoltage fault condition. I<sub>REVERSE</sub> is defined as  $V_{CS-} - V_{CS+}$  and must be greater than 0.02V (MAX8555A) or 0.04V (MAX8555) (typ) for a reverse-current fault. The I<sub>FORWARD</sub> and I<sub>REVERSE</sub> thresholds can be effectively increased by placing an external divider such as R8 and R9 as shown in Figure 4. The values shown increase the thresholds by 50%. When R8 and R9 are used, also add R10 (a parallel combination of R8 and R9) to eliminate any input offset errors caused by impedance differences and input-bias-current differences.

## Fault Conditions

The MAX8555/MAX8555A have an open-drain FAULT output that signals overvoltage, undervoltage, or reverse-current fault conditions. During a fault condition, FAULT is pulled to GND, the charge pump shuts down, and GATE discharges to CS- in 200ns (typ). See Table 1 for fault modes.

## Undervoltage Fault

The MAX8555/MAX8555A turn off the external MOSFETs if  $V_{UVP}$  falls below the UVP threshold (0.4V). Connect UVP to the center of a resistor-divider from the input supply to GND. Once  $V_{UVP}$  rises above the UVP rising threshold (0.5V), FAULT clears and GATE is driven high. FAULT is not latched. Connect UVP to VL to disable the undervoltage-protection feature.

## Overvoltage Fault

The MAX8555/MAX8555A are protected from overvoltage conditions using an adjustable overvoltage-protection input. A resistor-divider from the output bus to GND with OVP connected to the center tap sets the overvoltage threshold. When  $V_{OVP}$  exceeds the OVP threshold (0.5V) and the device is in the I<sub>FORWARD</sub> condition

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Table 1. Fault Modes

FAULT MODE	CONDITIONS	GATE	FAULT	LATCHING
VL UVLO	$V_L < V_{Lok}$	LOW	High Impedance	NO
UVP Undervoltage Protection	$V_{UVP} < 0.4V$	LOW	LOW	NO
OVP Overvoltage Protection	$V_{OVP} > 0.5V$ $V_{CS+} > V_{CS-} + 0.01V$	LOW	LOW	YES
Reverse-Current Protection	$V_{CS+} < V_{CS-} - 0.04V$ (0.02V for MAX8555A) and GATE is on for > 2048 charge-pump cycles	LOW	LOW	YES
V <sub>DD</sub> Internal Overvoltage Protection	$V_{DD} > 14.5V$	LOW	LOW	NO

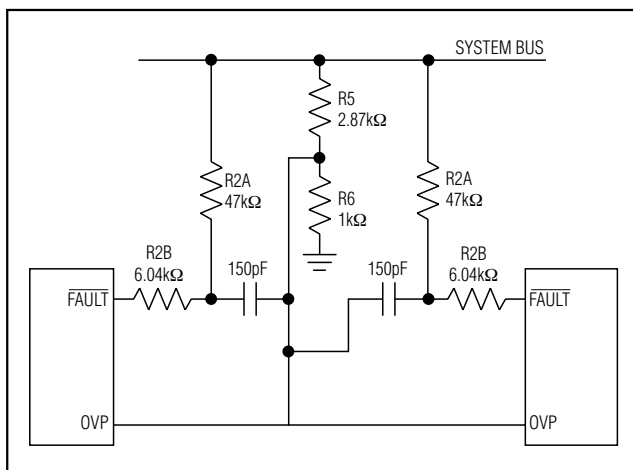


Figure 2. OVP Connection when Multiple MAX8555s Are Used

(defined as  $V_{CS+} > V_{CS-} + 0.01V$ ), the MAX8555/MAX8555A discharge GATE to GND and FAULT is latched low. If the I<sub>FORWARD</sub> condition is not detected, OVP is disabled. In redundant systems, when one input supply approaches its OVP threshold, some of the other input supplies may be pulled up with it, thereby tripping those OVP comparators with a slightly lower set point. The I<sub>FORWARD</sub> condition for the pulled-up supplies may not be detected until the first supply is shut down. An alternate application schematic for FAULT and OVP is shown in Figure 2. The FAULT output of the first channel, which has both OVP and I<sub>FORWARD</sub> conditions, temporarily reduces the common OVP signal by 125mV. This ensures that only the input supply, which is causing the overvoltage condition, is turned off in a redundant power-system application. Exceeding the OVP threshold causes the MAX8555/MAX8555A to be latched off. Toggle V<sub>DD</sub> or TIMER to reset the IC. Connect OVP to GND to disable the overvoltage-protection feature.

### Reverse-Current Fault

The MAX8555/MAX8555A provide a reverse-current fault-protection feature that turns off the oring MOSFET when a reverse-current fault condition is detected. Once a reverse-current fault condition is detected, the MAX8555/MAX8555A discharge GATE to GND and latch FAULT low. Toggle V<sub>DD</sub>, VL, or TIMER to reset the IC. The reverse-current-protection feature is blanked for 2048 charge-pump cycles at startup.

### Selecting the TIMER Resistor

Connect a resistor from TIMER to GND to set the internal charge pump's frequency of operation. Determine the TIMER resistor with the following equation:

$$R_{TIMER} = \frac{1.25V}{100\mu A - \frac{f}{5kHz/\mu A}}$$

Drive TIMER above 1.5V for the maximum charge-pump frequency (550kHz). Drive TIMER below 0.5V to disable the charge pump and shut down the MAX8555/MAX8555A.

### Selecting the GATE Capacitor and GATE Resistor

The charge pump uses an internal monolithic transfer capacitor to charge the external MOSFET gates. Normally, the external MOSFET's gate capacitance is sufficient to serve as a reservoir capacitor. To slow down turn-on times further, add a small capacitor between GATE and GND. Adding a small resistor between GATE and the gate of the Oring MOSFET reduces the high-frequency ringing due to gate trace inductance. However, the resistor increases the turn-off time.

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## Applications Information

**MAX8555/MAX8555A**

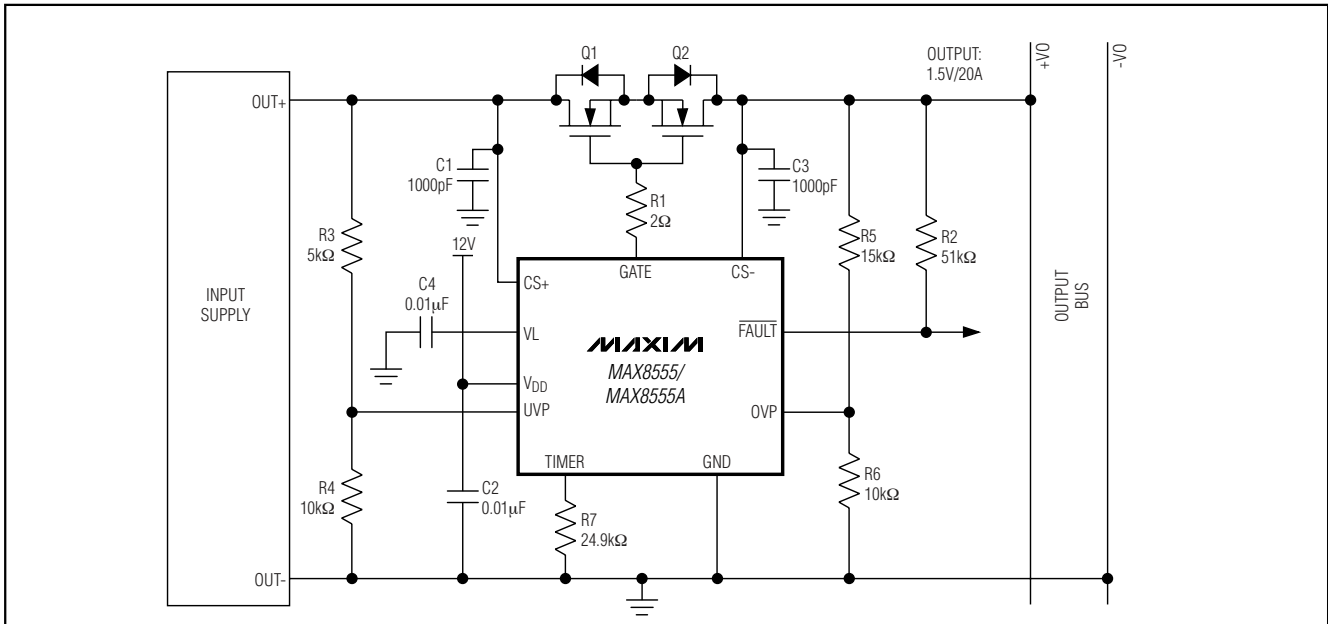


Figure 3. Application Circuit for 12V IC Supply Voltage

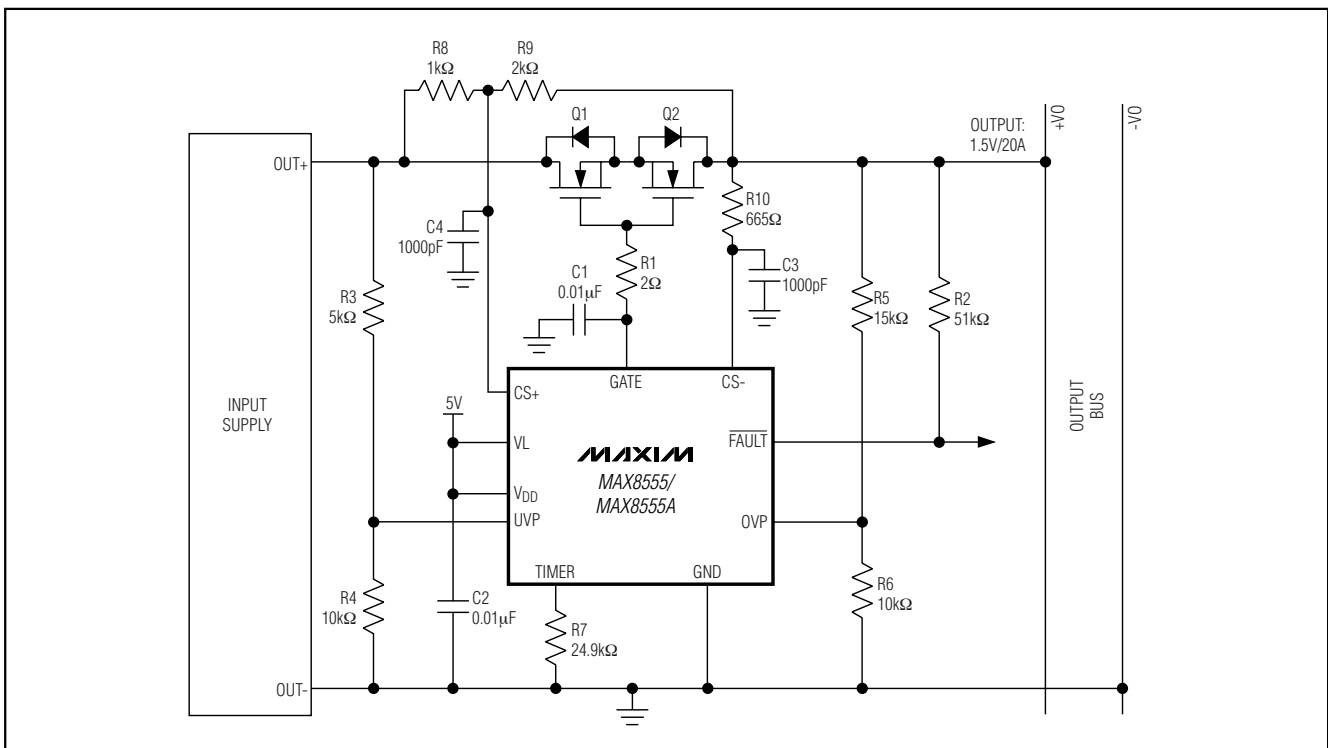


Figure 4. Application Circuit for 5V IC Supply Voltage

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## Set the UVP Fault Threshold

Use a resistor-divider from the input supply to GND with the center tap connected to UVP to set the undervoltage threshold. Use a 10kΩ resistor from UVP to GND (R4 in Figure 4) and calculate R3 as follows:

$$R_3 = R_4 \left( \frac{V_{UV}}{V_{UVP}} - 1 \right)$$

where  $V_{UV}$  is the desired undervoltage trip point and  $V_{UVP}$  is the UVP reference threshold (0.4V typ). Connect UVP to VL to disable the undervoltage-protection feature.

## Set the OVP Fault Threshold

For a single-supply application, use a resistor-divider from the output bus to GND with the center tap connected to OVP to set the overvoltage threshold. Use a 10kΩ resistor from OVP to GND (R6 in Figure 4) and calculate R5 as follows:

$$R_5 = R_6 \left( \frac{V_{OV}}{V_{OVP}} - 1 \right)$$

where  $V_{OV}$  is the desired overvoltage threshold and  $V_{OVP}$  is the OVP reference threshold (0.5V typ). Connect OVP to GND to disable the overvoltage-protection feature.

For (n + 1) applications, the required circuit values are:

$$R_6 = 1k\Omega$$

$$R_5 = R_6 \times \left[ \frac{V_{OV}}{V_{OVP}} - 1 \right]$$

$$R_{2A} = 47k\Omega$$

$$R_{2B} = 2 \times R_5$$

where the resistors are as shown in Figure 2.

## MOSFET Selection

The MAX8555/MAX8555A drive N-channel MOSFETs. The most important specification of the MOSFETs is  $R_{DS(ON)}$ . As load current flows through the external MOSFET,  $V_{DS}$  is generated from source to drain due to the MOSFET's on-resistance,  $R_{DS(ON)}$ . The MAX8555/MAX8555A monitor  $V_{DS}$  of the MOSFETs at all times to determine the state of the monitored power supply. Selecting a MOSFET with a low  $R_{DS(ON)}$  allows more current to flow through the MOSFETs before the MAX8555/MAX8555A detect reverse-current ( $I_{REVERSE}$ ) and forward-current ( $I_{FORWARD}$ ) conditions.

## Using Two MOSFETs

Two MOSFETs must be used for overvoltage protection. When using two external MOSFETs, the monitored voltage equation becomes:

$$V_{DSTOTAL} = R_{DS(ON)1} \times I_{LOAD} + R_{DS(ON)2} \times I_{LOAD}$$

## Using One MOSFET

A single MOSFET can be used if the overvoltage-protection function is not needed. Connect CS+ to the source of the MOSFET and CS- to the drain of the MOSFET.

## Calculating GATE Current

The charge-pump output current is proportional to both oscillator frequency and  $V_{VL}$ . There is also a small internal load of approximately 6MΩ. The GATE current for a given  $V_{VL}$  and  $R_{TIMER}$  is calculated as:

$$I_{GATE} \approx \left\{ 24.12 \times \left[ \frac{(V_L - 0.8)}{3.4} \right] \times \left[ 1 - \left[ \frac{12,500}{R_{TIMER}} \right] \right] - 0.4 \right\} \mu A$$

## Layout Guidelines

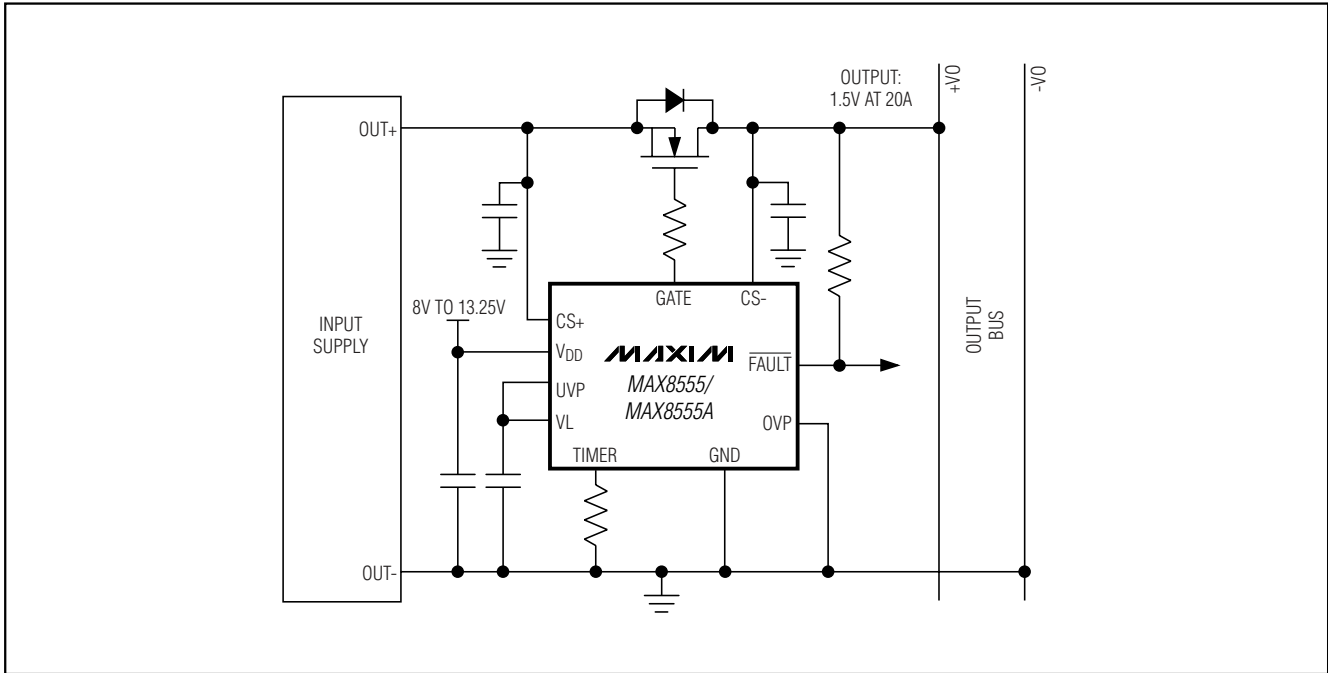
It is important to keep all traces as short as possible and to maximize the high-current trace dimensions to reduce the effect of undesirable parasitic inductance. The MOSFET dissipates a fair amount of heat due to the high currents involved, especially during an over-current condition. To dissipate the heat generated by the MOSFET, make the power traces very wide with a large amount of copper area and place the MAX8555 as close as possible to the drain of the external MOSFET. A more efficient way to achieve good power dissipation on a surface-mount package is to lay out two copper pads directly under the MOSFET package on both sides of the board. Use enlarged copper mounting pads on the top side of the board. Use a ground plane to minimize impedance and inductance. In addition to the usual high-power considerations, here are three tips to prevent false faults:

- 1) Kelvin connect CS+ and CS- to the external MOSFET and route the two traces in parallel, as close as possible, back to the IC.
- 2) Bypass  $V_{DD}$  with a 0.01μF capacitor to ground and bypass CS+ and CS- with a 1000pF capacitor to ground.
- 3) Make the traces connected to UVP and OVP as short as possible.

Refer to the MAX8555/MAX8555A evaluation kit for an example of good PC board layout.

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## Typical Operating Circuit



**MAX8555/MAX8555A**

## Chip Information

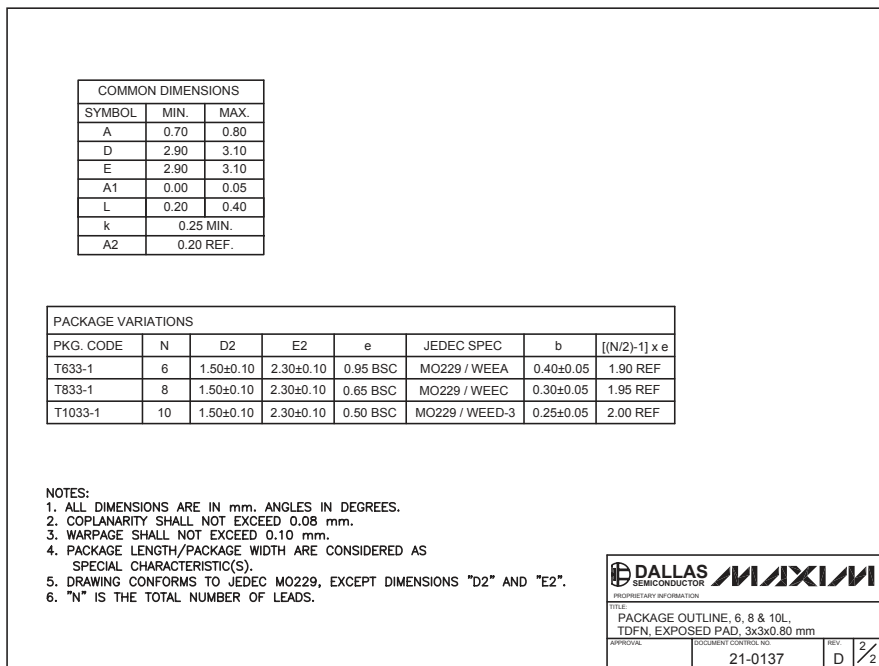
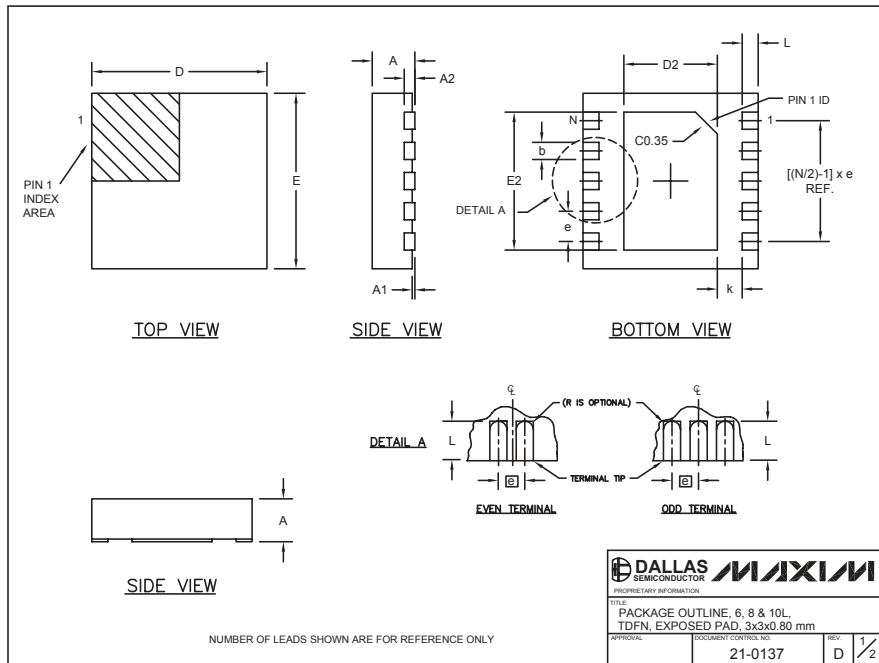
TRANSISTOR COUNT: 2309

PROCESS: BiCMOS

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## Package Information

(The package drawing(s) in this data sheet may not reflect the most current specifications. For the latest package outline information, go to [www.maxim-ic.com/packages](http://www.maxim-ic.com/packages).)



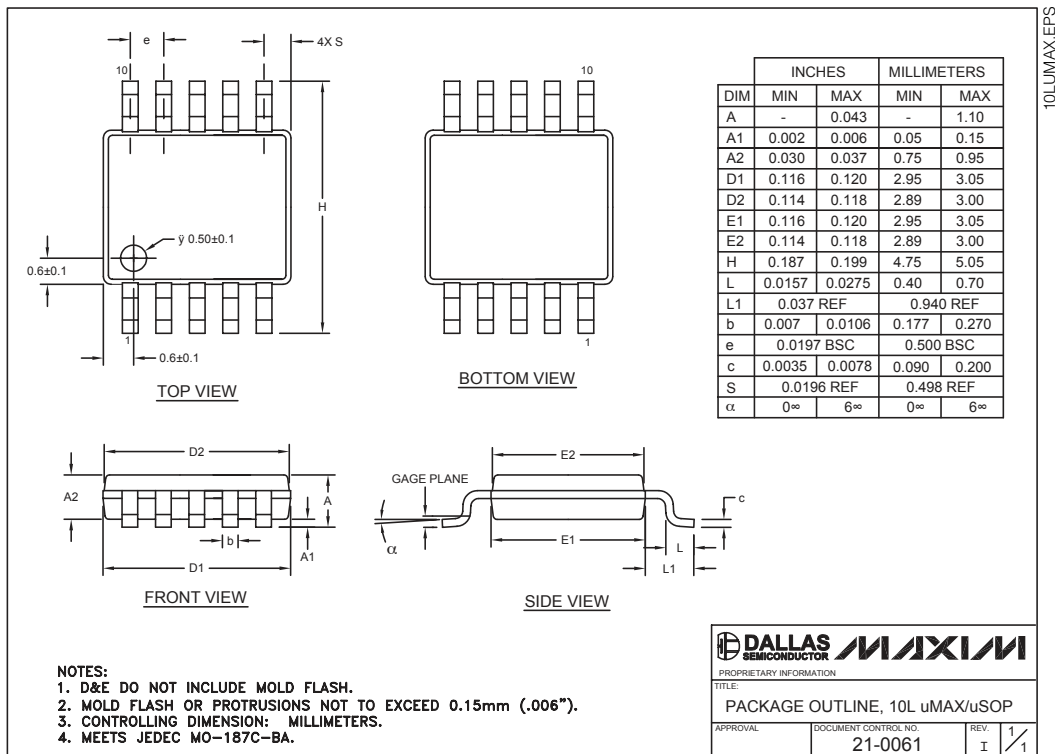


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## Package Information (continued)

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MAX8555/MAX8555A



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