19-2077; Rev 5; 1/07

-100V, SOT23/TDFN, Simple Swapper Hot-Swap Controllers

General Description

The MAX5900/MAX5901 are SOT23/TDFN hot-swap controllers that allow a circuit card to be safely hot-plugged into a live backplane without causing a glitch on the power-supply rail. These devices operate from -9V to -100V and provide the simplest hot-swap solution by eliminating all external components except an external n-channel MOSFET.

The MAX5900/MAX5901 limit the inrush current to the load and provide a circuit-breaker function for overcurrent protection. During startup, the circuit-breaker function is disabled and the MAX5900/MAX5901 limit the inrush current by gradually turning on the external MOSFET. Once the external MOSFET is fully enhanced, the circuit-breaker function is enabled and the MAX5900/MAX5901 provide overcurrent protection by monitoring the voltage drop across the external MOSFET's on-resistance.

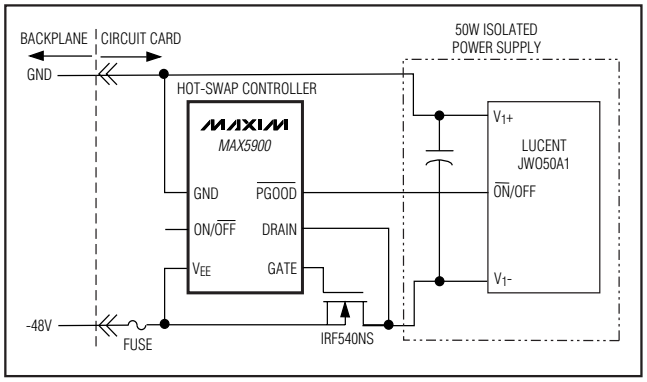
The MAX5900/MAX5901 include an undervoltage lockout (UVLO) function, ON/$\overline{OFF}$ control input, and a power-good status output, $\overline{PGOOD}$ (MAX5900) or PGOOD (MAX5901). A built-in thermal shutdown feature is also included to protect the external MOSFET in case of overheating.

The MAX5900/MAX5901 offer latched or autoretry fault management and are available with 200mV, 300mV, or 400mV circuit-breaker thresholds. Both the MAX5900 and MAX5901 are available in small SOT23 and TDFN packages, and are specified for the extended -40°C to +85°C temperature range. For specific ordering information see the *Selector Guide* at the end of the data sheet.

Applications

Telecom Line Cards
Network Routers
Base-Station Line Cards
Network Switches
Servers

Typical Operating Circuits



Features

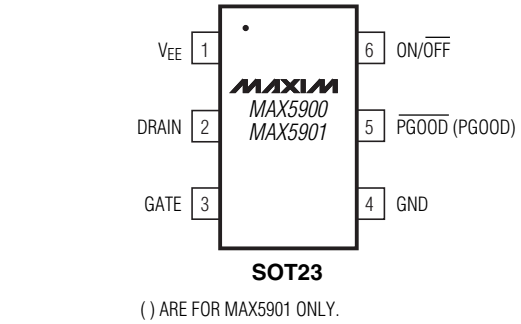
- ♦ **Wide -9V to -100V Operation**
- ♦ **Requires No External Sense Resistor**
- ♦ **Drives External N-Channel MOSFET**
- ♦ **Limits Inrush Current**
- ♦ **Circuit-Breaker Function**
- ♦ **Less than 1mA Quiescent Current**
- ♦ **ON/$\overline{OFF}$ Input Permits Load Power-Supply Control and Sequencing**
- ♦ **Adjustable Undervoltage Lockout**
- ♦ **Power-Good Output with 100V Rating**
- ♦ **Latching or Automatic Retry Fault Management**
- ♦ **Thermal Shutdown Helps Protect the External MOSFET**
- ♦ **Space-Saving 6-Pin SOT23 and TDFN Packages**

Ordering Information

PART	TEMP RANGE	PIN-PACKAGE	PKG CODE
MAX5900_ _EUT+T*	-40°C to +85°C	6 SOT23-6	U6F-6
MAX5900_ _ETT+T*	-40°C to +85°C	6 TDFN-EP**	T633-2
MAX5901_ _EUT+T*	-40°C to +85°C	6 SOT23-6	U6F-6
MAX5901_ _ETT+T*	-40°C to +85°C	6 TDFN-EP**	T633-2

**For specific part numbers, see Selector Guide at end of data sheet.*
+Denotes lead-free package.
***EP = Exposed pad.*

Pin Configurations



Pin Configurations continued at end of data sheet.

Typical Operating Circuits continued at end of data sheet.

Simple Swapper is a trademark of Maxim Integrated Products, Inc.

For pricing, delivery, and ordering information, please contact Maxim/Dallas Direct! at 1-888-629-4642, or visit Maxim's website at www.maxim-ic.com.

-100V, SOT23/TDFN, Simple Swapper Hot-Swap Controllers

ABSOLUTE MAXIMUM RATINGS

Terminal Voltage (with respect to GND, unless otherwise noted)
V_{EE}, DRAIN, PGOOD, $\overline{PGOOD}$ .....-120V to +0.3V
ON/$\overline{OFF}$ to V_{EE} .....-0.3V to +4V
GATE to V_{EE} ..... -0.3V to +12V
Current into Any Pin.....±3mA

Continuous Power Dissipation (T_A = +70°C)
6-Pin SOT23 (derate 9.1mW/°C above +70°C).....727mW
6-Pin TDFN (derate 18.2mW/°C above +70°C) 1454mW
Junction to Case Thermal Resistance, θ_{JC} (TDFN) .....8.5°C/W
Maximum Junction Temperature .....+150°C
Storage Temperature Range .....-60°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_{EE} = -9V to -100V, GND = 0V, ON/$\overline{OFF}$ open circuit, T_A = -40°C to +85°C, unless otherwise noted. Typical values are at V_{EE} = -48V and T_A = +25°C.) (Notes 1, 2)

PARAMETER	SYMBOL	CONDITIONS		MIN	TYP	MAX	UNITS
Supply Voltage	V_{EE}			-100		-9	V
Supply Current	I_{GND}	Measured at GND			0.5	1.3	mA
External Gate Drive	V_{GS}	V_{GATE} - V_{EE}	V_{EE} = -36V to -72V	7.5	9.5	11.6	V
			V_{EE} = -100V	8	10	11.6	
			V_{EE} = -9V	6	7		
Load Voltage Slew-Rate Magnitude	SR	l dV_{DRAIN}/dt l, C_{LOAD} = 10µF, V_{EE} = -9V to -36V		4.5	10	17	V/ms
Default UVLO	V_{UVLO}	lV_{EE}l increasing		-34.5	-31.5	-28.5	V
UVLO Hysteresis					3.5		V
ON/$\overline{OFF}$ Input Resistance	$R_{ON/\overline{OFF}}$			20	32	50	kΩ
Drain to V_{EE} Resistance	R_{DVEE}				466		kΩ
ON/$\overline{OFF}$ Reference Threshold	$V_{ON/\overline{OFF}}$	($V_{ON/\overline{OFF}}$ - V_{EE}) increasing		1.14	1.26	1.38	V
ON/$\overline{OFF}$ Hysteresis					140		mV
Start Delay (Note 3)	t_{ON}			150	300	500	ms
ON/$\overline{OFF}$ Off Delay (Note 4)	t_{OFF}	V_{GATE} - V_{EE} < 1V		9	20	32	ms
Circuit-Breaker Threshold	V_{CB}	V_{DRAIN} - V_{EE}	MAX590_ _AEUT	170	200	240	mV
			MAX590_ _BEUT	265	300	345	
			MAX590_ _CEUT	365	400	455	
Circuit-Breaker Delay (Note 5)	t_{CB}	(V_{DRAIN} - V_{EE}) > V_{CB} until (V_{GATE} - V_{EE}) < 1V, 200mV overdrive step	C_{GATE} = 1nF		1.5	3	µs
			C_{GATE} = 4.7nF		2.5	4.5	
			C_{GATE} = 10nF		4	6	
Restart Delay (Note 3)	t_{RS}	After circuit-breaker event, MAX590_A_EUT only		150	300	500	ms

ELECTRICAL CHARACTERISTICS (continued)

(V_{EE} = -9V to -100V, GND = 0V, ON/$\overline{OFF}$ open circuit, T_A = -40°C to +85°C, unless otherwise noted. Typical values are at V_{EE} = -48V and T_A = +25°C.) (Notes 1, 2)

PARAMETER	SYMBOL	CONDITIONS	MIN	TYP	MAX	UNITS
$\overline{PGOOD}$ (PGOOD) Assertion Threshold (Note 6)	V_{PG}	V_{DRAIN} - V_{EE}; MAX590_A, MAX590_L only		0.75 × V_{CB}		mV
$\overline{PGOOD}$ (PGOOD) Output Low Voltage	V_{OL}	MAX5900, $V_{\overline{PGOOD}}$ - V_{EE}, I_{OL} = 1mA; MAX5901, V_{PGOOD} - V_{EE}, I_{OL} = 1mA		0.6	1.65	V
Power-Good Output Open-Drain Leakage Current	I_{OH}	$V_{\overline{PGOOD}}$ - V_{EE} = 100V (MAX5900); V_{PGOOD} - V_{EE} = 100V (MAX5901)		0.2	10	µA
Thermal Shutdown Temperature	T_{SD}	Junction temperature		+125		°C
Thermal Shutdown Hysteresis	T_{HY}			15		°C

Note 1: All currents into device pins are positive, all currents out of device pins are negative, and all voltages are referenced to GND, unless otherwise noted.

Note 2: All specifications are 100% tested at T_A = +25°C. Specifications over -40°C to +85°C are guaranteed by characterization.

Note 3: This is the delay time from a valid on condition until V_{GS} begins rising. Valid on conditions are: the device is not in undervoltage lockout; ON/$\overline{OFF}$ is not driven low; and the device is not in thermal shutdown.

Note 4: This is the delay from a valid low on ON/$\overline{OFF}$ until V_{GS} falls. Pulses on ON/$\overline{OFF}$ less than t_{OFF} are ignored, offering glitch immunity.

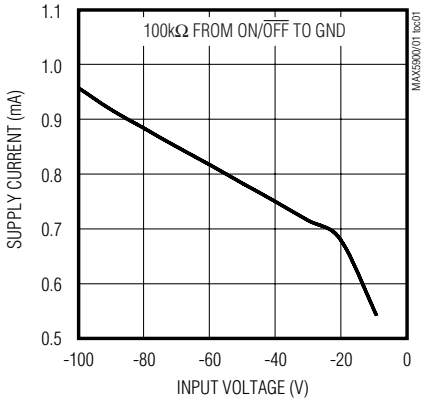
Note 5: Guaranteed by design, not production tested.

Note 6: For a detailed description, see the *Power-Good Output* section.

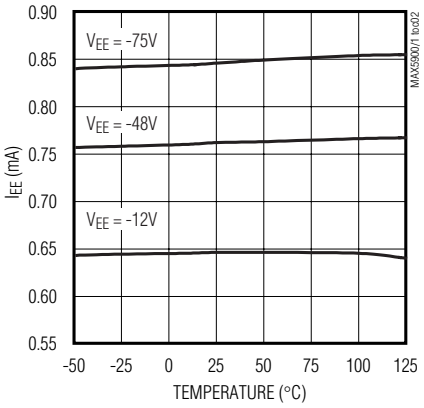
Typical Operating Characteristics

(V_{EE} = -48V, GND = 0V, and T_A = +25°C, unless otherwise noted. See Figure 6 for test circuits.)

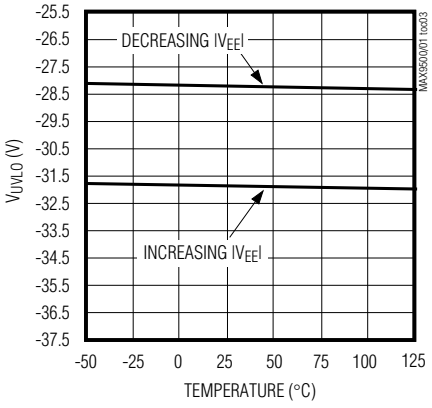
SUPPLY CURRENT vs. INPUT VOLTAGE



SUPPLY CURRENT vs. TEMPERATURE



DEFAULT UNDERVOLTAGE LOCKOUT vs. TEMPERATURE

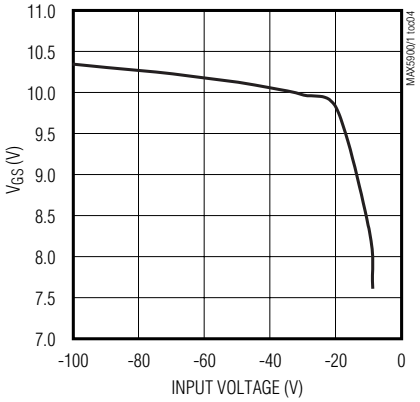


-100V, SOT23/TDFN, Simple Swapper Hot-Swap Controllers

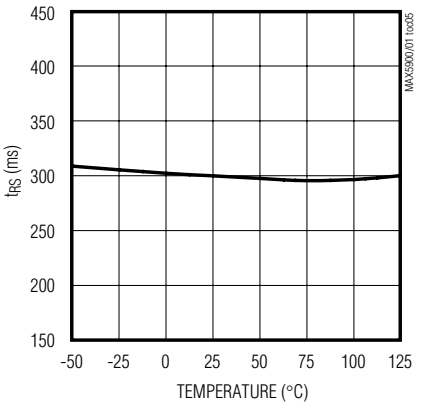
Typical Operating Characteristics (continued)

(V_{EE} = -48V, GND = 0V, and T_A = +25°C, unless otherwise noted. See Figure 6 for test circuits.)

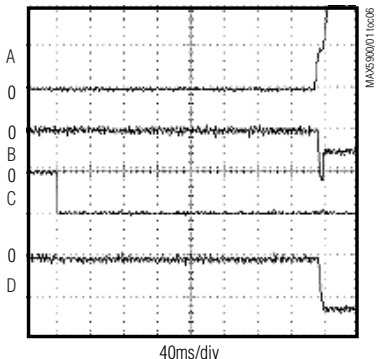
GATE DRIVE VOLTAGE vs. INPUT VOLTAGE



RESTART DELAY vs. TEMPERATURE

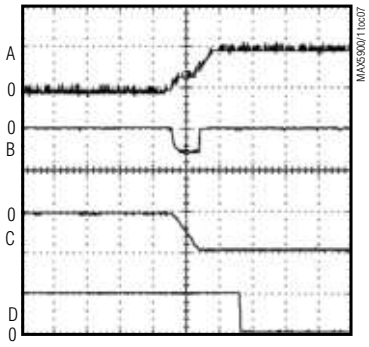


STARTUP WAVEFORMS (R_L = 90Ω, C_L = 100µF)



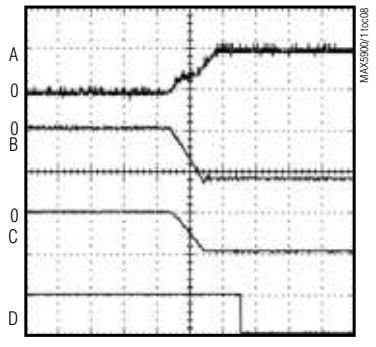
A: V_{GS}, 5V/div C: V_{EE}, 50V/div
B: I_{IN}, 1A/div D: V_{DRAIN}, 40V/div

STARTUP WAVEFORMS (R_L = OPEN, C_L = 10µF)



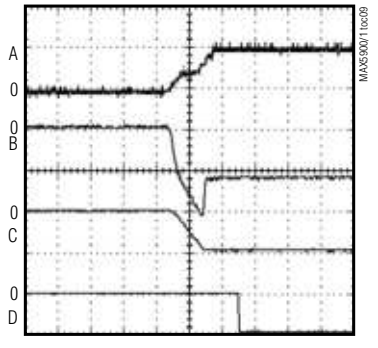
A: V_{GS}, 10V/div C: $V_{\overline{OUT}}$, 50V/div
B: I_{IN}, 200mA/div D: $\overline{PGOOD}$, 50V/div

STARTUP WAVEFORMS (R_L = 40Ω, C_L = 10µF)



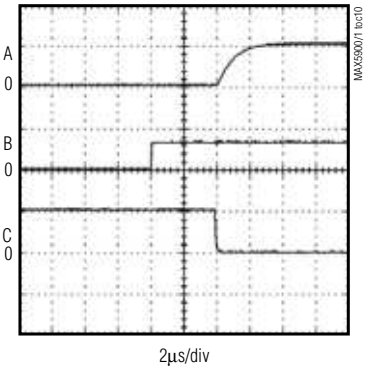
A: V_{GS}, 10V/div C: $V_{\overline{OUT}}$, 50V/div
B: I_{IN}, 1A/div D: $\overline{PGOOD}$, 50V/div

STARTUP WAVEFORMS (R_L = 40Ω, C_L = 100µF)



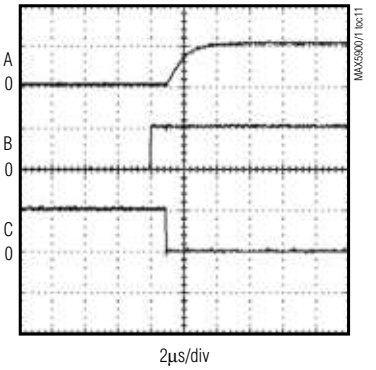
A: V_{GS}, 10V/div C: $V_{\overline{OUT}}$, 50V/div
B: I_{IN}, 1A/div D: PGOOD, 50V/div

CIRCUIT-BREAKER EVENT (C_{GATE} = 1000pF, $V_{OVERDRIVE}$ = 20mV)



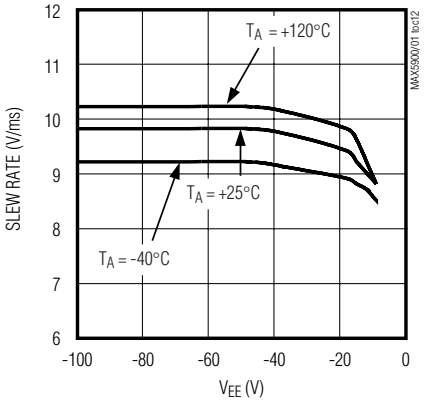
D: $\overline{PGOOD}$, 50V/div C: V_{GS}, 10V/div
B: V_{DS}, 500mV/div

CIRCUIT-BREAKER EVENT (C_{GATE} = 1000pF, $V_{OVERDRIVE}$ = 200mV)



D: $\overline{PGOOD}$, 50V/div C: V_{GS}, 10V/div
B: V_{DS}, 500mV/div

SLEW RATE vs. V_{EE}



Pin Description

PIN		NAME	FUNCTION
MAX5900	MAX5901		
1	1	V_{EE}	Negative Supply Voltage Input and External n-Channel MOSFET Source Connection
2	2	DRAIN	Drain Sense Input for External n-Channel MOSFET. Connect DRAIN as close as possible to the MOSFET's drain and use wide circuit traces to assure good thermal coupling between the MAX5900/MAX5901 and the MOSFET (see the *Layout Guidelines* section).
3	3	GATE	Gate Drive Output for External n-Channel MOSFET
4	4	GND	Ground Connection.
5	—	$\overline{PGOOD}$	Power-Good Output. $\overline{PGOOD}$ is an n-channel, open-drain, active-low output, referenced to V_{EE}.
—	5	PGOOD	Power-Good Output. PGOOD is an n-channel, open-drain, active-high output, referenced to V_{EE}.
6	6	ON/$\overline{OFF}$	ON/$\overline{OFF}$ Control Input. ON/$\overline{OFF}$ is referenced to V_{EE}. Drive ON/$\overline{OFF}$ above 1.38V or leave unconnected to enable the device. Drive ON/$\overline{OFF}$ below 1V to disable the device. ON/$\overline{OFF}$ is also used to adjust the UVLO threshold. See the *Undervoltage Lockout* section in the *Applications Information*. Internally clamped to nominally 3V through a 1kΩ resistor (see Figure 1).
—	—	EP	Exposed Pad (TDFN only). Connect to V_{EE}.

Detailed Description

The MAX5900/MAX5901 are integrated hot-swap controller ICs contained in 6-pin SOT23/TDFN packages. They allow a board to be safely hot plugged into a live backplane without causing a glitch on the power-supply rail. They are well suited for -48V telecom power systems, allowing a cost-effective, simple, and compact design. The MAX5900/MAX5901 operate from -9V to -100V to cover the standard telecom voltage range, and to serve more generalized applications. These devices require only an external n-channel power MOSFET to provide hot-swap control. Figure 1 shows a functional diagram of the MAX5900/MAX5901.

The MAX5900/MAX5901 control an external n-channel power MOSFET placed in the negative power-supply pathway. When power is first applied, the MAX5900/MAX5901 keep the MOSFET turned off. The MAX5900/MAX5901 hold the MOSFET off indefinitely if ON/$\overline{OFF}$ is held low, if the supply voltage is below the undervoltage lockout level, or if the die temperature exceeds +125°C. If none of these conditions exist for 300ms (typ), the MAX5900/MAX5901 begin to gradually turn on the MOSFET. During this turn-on phase, the MAX5900/MAX5901 slowly enhance the MOSFET,

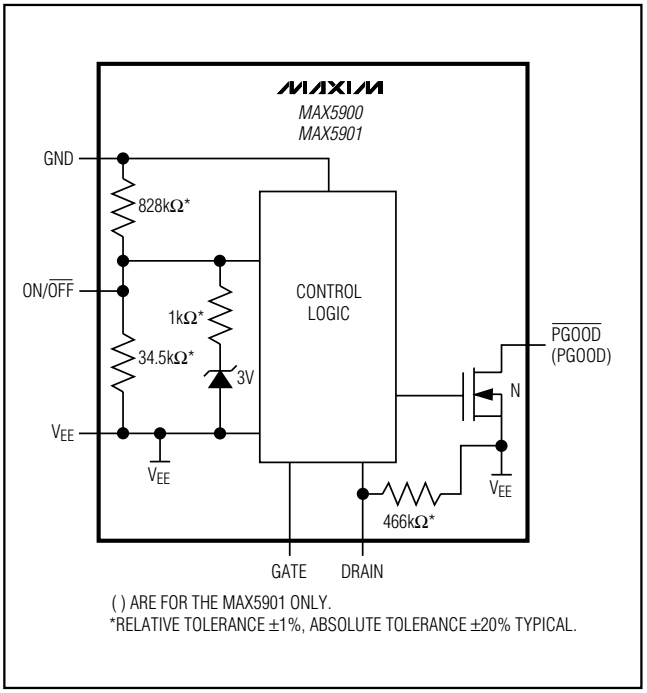


Figure 1. Functional Diagram

-100V, SOT23/TDFN, Simple Swapper Hot-Swap Controllers

allowing the voltage on the load, i.e. the drain of the MOSFET, to fall no faster than 10V/ms (typ). The inrush current to the load is thus limited to a level proportional to the load capacitance, and the constant load voltage slew rate. After the MOSFET is fully enhanced, and the load voltage is settled to its final value, the MAX5900A/MAX5901A and MAX5900L/MAX5901L monitor the voltage drop from the MOSFET's drain-to-source (V_{DS}). If the voltage drop exceeds 75% of the circuit-breaker threshold the MAX5900A/MAX5901A or MAX5900L/MAX5901L turn off the MOSFET, disconnecting the load immediately. Because the circuit-breaker function is not activated until the MOSFET is fully enhanced, it takes approximately 10ms for the MAX5900A/MAX5901A or MAX5900L/MAX5901L to react to an output short circuit at startup. If no circuit-breaker fault exists, the power-good output is asserted. Then, if any of four conditions exist, the power-good output deasserts and the MOSFET is turned off . The four conditions are: the voltage across the MOSFET exceeds the circuit-breaker threshold; the supply voltage magnitude falls below the undervoltage lockout level; the die temperature exceeds +125°C; or ON/$\overline{OFF}$ is forced low. After a circuit-breaker fault, the MAX5900L/MAX5901L keep the MOSFET off until the power is cycled, or the part is reset by toggling ON/$\overline{OFF}$ low for at least 20ms (typ). After a circuit-breaker fault, the MAX5900A/MAX5901A automatically restart in 300ms (typ). All versions automatically restart after a thermal fault, or an undervoltage shutdown, if the fault condition goes away for at least 300ms (typ).

ON/$\overline{OFF}$ offers external control of the MAX5900/MAX5901, facilitating power-supply sequencing, and may also be used to change the UVLO level. UVLO keeps the external MOSFET switched off as long as the magnitude of the input voltage is less than a desired level.

A power-good output, $\overline{PGOOD}$ (MAX5900) or PGOOD (MAX5901), asserts when the external MOSFET is fully enhanced and the drain-source voltage is at least 25% below the circuit-breaker threshold. $\overline{PGOOD}$ and PGOOD are open-drain outputs referenced to V_{EE}, and can withstand up to 100V above V_{EE}.

A thermal shutdown feature protects the external MOSFET by turning it off if the die temperature of the MAX5900/MAX5901 exceeds +125°C. The MAX5900/MAX5901 must be in good thermal contact with the external MOSFET. See the *Layout Guidelines* section in the *Applications Information*.

A circuit-breaker function monitors the voltage across the external MOSFET, V_{DS}, and turns off the MOSFET if V_{DS} exceeds the circuit-breaker threshold, V_{CB}. The circuit-breaker function is enabled after the MOSFET is fully enhanced. Three threshold voltage options are available—200mV, 300mV, and 400mV. One version is available with no circuit-breaker function. circuit-breaker fault management for the MAX5900/MAX5901 is offered with two different configurations—latched and automatic retry.

Latched Circuit Breaker

After a circuit-breaker trip event, the latched versions (MAX5900L/MAX5901L) drive GATE to V_{EE}, turning off the external MOSFET, and $\overline{PGOOD}$ (PGOOD) is deasserted. A latched-off condition needs to be reset by toggling ON/$\overline{OFF}$ low for at least 20ms, or by cycling the power supply, V_{EE}.

Automatic Retry Circuit Breaker

After a circuit-breaker trip event, the automatic retry versions (MAX5900A/MAX5901A) drive GATE to V_{EE}, turning off the external MOSFET, and $\overline{PGOOD}$ (PGOOD) is deasserted. If the start conditions are met for a full 300ms (t_{RS}) the start sequence is initiated. The start conditions are: the device is not in UVLO; ON/$\overline{OFF}$ is not driven low; and the device is not in thermal shutdown.

No Circuit Breaker

For the versions without a circuit-breaker MAX5900N (MAX5901N), $\overline{PGOOD}$ (PGOOD) is asserted when the MOSFET is fully enhanced. Once powered up, the MAX5900N/MAX5901N ignore the MOSFET drain-to-source voltage (V_{DS}) for applications where a circuit-breaker function is not desired.

Applications Information

ON/$\overline{OFF}$ Control Input

The ON/$\overline{OFF}$ control input provides three hot-swap functions: external ON/$\overline{OFF}$ control; setting of the UVLO level; and resetting after a circuit-breaker event has caused the MAX5900L/MAX5901L to turn off the external MOSFET. Pulling ON/$\overline{OFF}$ to V_{EE} for at least 20ms (t_{OFF}) forces the MAX5900/MAX5901 to turn off the external MOSFET (see Figure 2 for a circuit example). To reset the MAX5900L/MAX5901L after a circuit-breaker event, toggle ON/$\overline{OFF}$ to V_{EE} for at least 20ms (t_{OFF}).

ON/$\overline{OFF}$ can be used to sequence power supplies. Connecting a capacitor from ON/$\overline{OFF}$ to V_{EE} will delay the rise of ON/$\overline{OFF}$ proportional to the capacitance and input impedance of ON/$\overline{OFF}$, typically 32kΩ (Figure 3).

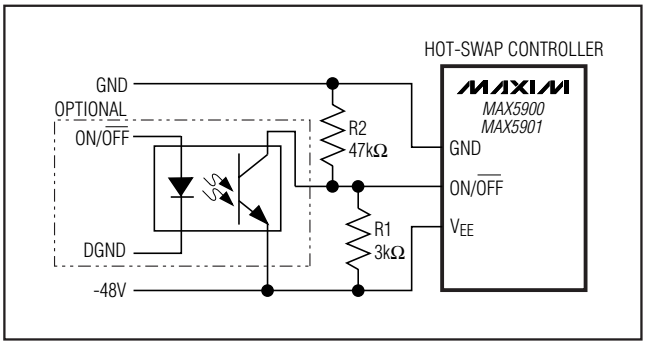


Figure 2. Programmed -20V Lockout With Optional Optocoupler On/Off Control

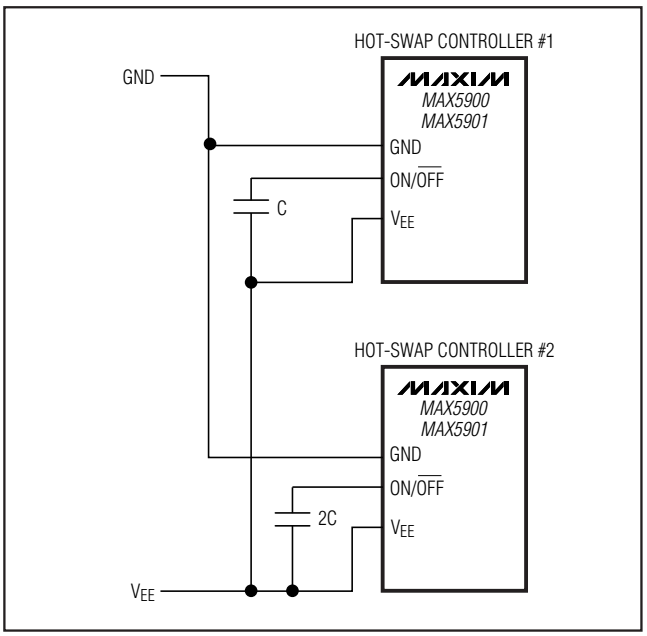


Figure 3. Power-Supply Sequencing

Turn-On and Turn-Off Delays

After power is applied, or ON/$\overline{OFF}$ is released, there is a 300ms delay (t_{ON}) before the gate ramp is started. This delay is also the automatic restart time delay.

In the event of a circuit-breaker condition or an over-temperature fault condition, the turn-off delay is less than 2µs. An undervoltage condition must exist for at least 20ms (t_{OFF}) before the MAX5900/MAX5901 turn off the external MOSFET. ON/$\overline{OFF}$ must be held low for at least 20ms (t_{OFF}) before the MAX5900/MAX5901 turn off the external MOSFET. Turn-off delay minimizes spurious shutdowns due to noisy signals or momentary voltage spikes, as well as preventing accidental resetting of the circuit-breaker latch (MAX5900L/MAX5901L).

Thermal Shutdown

A thermal shutdown feature helps protect the external MOSFET. If the die temperature of the MAX5900/MAX5901 exceeds +125°C, the MOSFET is turned off. For accurate performance, the MAX5900/MAX5901 must be in close thermal contact with the external MOSFET (see the *Layout Guidelines* section). Due to the low power dissipation of the MAX5900/MAX5901, its junction temperature will typically be within a few degrees of the MOSFET. All versions of the MAX5900/MAX5901 automatically restart from a temperature fault when the junction temperature drops below +110°C.

Undervoltage Lockout

The MAX5900/MAX5901 turn off the external MOSFET if the magnitude of the input voltage is below the level set by ON/$\overline{OFF}$ for longer than 20ms (t_{OFF}). If ON/$\overline{OFF}$ is left unconnected, the lockout voltage (V_{UVLO}) defaults to -31.5V. V_{UVLO} may also be set to any value within the power-supply range by using external resistors. To set the lockout voltage to a value between -9V and -100V, use a resistor-divider connected between GND and V_{EE}, with the center node of the divider connected to ON/$\overline{OFF}$. For example, use a 3kΩ resistor (R1 in Figure 2) from ON/$\overline{OFF}$ to V_{EE} and calculate the other resistor, R2, using:

$$R2 = R1 \times \left(\frac{V_{UVLO}}{1.26} - 1 \right)$$

where V_{UVLO} is the desired lockout voltage, and $V_{ON/OFF}$ is the ON/$\overline{OFF}$ reference threshold specified in the *Electrical Characteristics* table (typically 1.26V).

Figure 2 shows an example circuit with V_{UVLO} set for -20V. To defeat the UVLO, simply connect a single 100kΩ resistor between ON/$\overline{OFF}$ and GND, as shown in Figure 4.

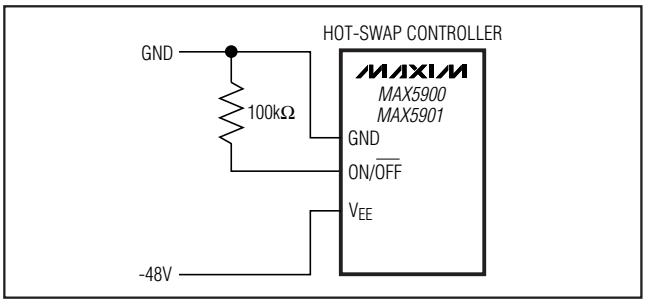


Figure 4. Defeating Undervoltage Lockout

-100V, SOT23/TDFN, Simple Swapper Hot-Swap Controllers

Power-Good Output

The power-good output, $\overline{PGOOD}$ (PGOOD), is open-drain and asserts when the external MOSFET is fully enhanced and V_{DS} is less than V_{PG} (75% of the circuit-breaker threshold, V_{CB}). For versions without the circuit-breaker function (MAX5900N/MAX5901N), $\overline{PGOOD}$ (PGOOD) asserts when the external MOSFET is fully enhanced.

$\overline{PGOOD}$ (PGOOD) deasserts within 2µs when a circuit-breaker event occurs or if the die temperature exceeds +125°C. $\overline{PGOOD}$ (PGOOD) deasserts if $|V_{EE}| < |V_{UVLO}|$ for longer than 20ms or ON/$\overline{OFF}$ is held low for longer than 20ms.

The MAX5900 $\overline{PGOOD}$ is active-low and the MAX5901 PGOOD is active-high. Both are open-drain N-channel MOSFETs with their sources connected to V_{EE}, and can withstand up to 100V.

Selecting a Circuit-Breaker Threshold

The MAX5900A/MAX5901A and the MAX5900L/MAX5901L offer a circuit-breaker function to protect the external MOSFET and the load from the potentially damaging effects of excessive current. As load current flows through the external MOSFET, a voltage, V_{DS}, is generated from drain to source due to the MOSFET's on-resistance $R_{DS(ON)}$. The MAX5900A/MAX5901A and MAX5900L/MAX5901L monitor V_{DS} when the external MOSFET is fully enhanced. If V_{DS} exceeds the circuit-breaker threshold, the external MOSFET is turned off and $\overline{PGOOD}$ (PGOOD) is deasserted.

To accommodate different MOSFETs and different load currents, the MAX5900/MAX5901 are available with circuit-breaker threshold voltages of 200mV, 300mV, and 400mV.

The circuit-breaker function is intended to disconnect the load if a gross overcurrent or short-circuit condition occurs. For calculating the circuit-breaker threshold, use the MOSFET's R_{ON} at the worst possible operating condition, and add a 25% overcurrent margin to the maximum circuit current. For instance, if a MOSFET has an R_{ON} of 0.06Ω at T_A = +25°C, and a normalized on-resistance factor of 1.75 at T_A = +130°C (from the MOSFET data sheet), the R_{ON} used for calculation is the product of these two numbers, or (0.06Ω) x (1.75) = 0.105Ω. Then, if the maximum current is expected to be 2A, using a 25% margin, the current for calculation is (2A) x (1.25) = 2.5A. The resulting minimum circuit-breaker threshold is then the product of these two results, or (0.105Ω) x (2.5A) = 0.263V. The next highest minimum available threshold is 0.265V of the MAX590_ _BEUT, which is an ideal choice given these parameters. Using this method to choose a circuit-breaker threshold allows the circuit to operate under worst-case conditions without causing a circuit-breaker fault, but the circuit-breaker function will still operate if a short-circuit or gross overcurrent condition occurs. See Table 1 for MOSFET suggestions. The MAX5900N/MAX5901N have no circuit-breaker function. For these parts choose an external MOSFET that meets the load requirements.

Determining Inrush Current

Determining a circuit's inrush current is necessary to help choose the proper MOSFET. The MAX5900/MAX5901 regulate the inrush current by means of controlling the load voltage slew rate, but inrush current is also a function of load capacitance. Determine inrush current using:

$$I = C \frac{dV}{dt} = C \times SR$$

where C is the load capacitance, and SR is the MAX5900/MAX5901 Load Voltage Slew-Rate Magnitude from the *Electrical Characteristics* table. For example, assuming a load capacitance of 100µF, and using the typical value of 10V/ms for the slew rate, the inrush current is 1A typical.

If the maximum possible Load Voltage Slew Rate is used, the maximum inrush current calculates to 1.7A. Choose a MOSFET with a maximum pulsed current specification that exceeds the maximum inrush current.

Suggested External MOSFETs

MAXIMUM I_{LOAD} (A)	SUGGESTED EXTERNAL MOSFET	SUGGESTED MAXIM PART
0.25	IRFL110	MAX590_ _CEUT
0.5	IRFL4310	MAX590_ _BEUT
1	IRFR3910	MAX590_ _CEUT
2	IRF540NS	MAX590_ _BEUT
3	IRF1310NS	MAX590_ _BEUT
4	IRF1310NS	MAX590_ _CEUT

V_{IN} = -9V to -90V

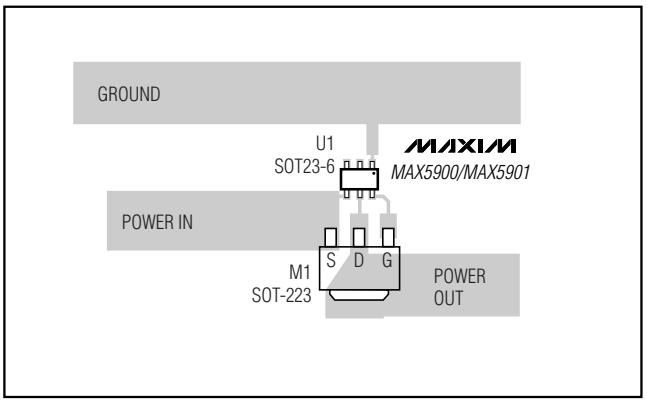


Figure 5. Circuit Board Layout Example

Layout Guidelines

Good thermal contact between the MAX5900/MAX5901 and the external MOSFET is essential for the thermal shutdown feature to operate effectively. Place the MAX5900/MAX5901 as close as possible to the drain of the external MOSFET, and use wide circuit board traces for good heat transfer. See Figure 5 for an example of a PC board layout.

Chip Information

TRANSISTOR COUNT: 678
PROCESS: BiCMOS

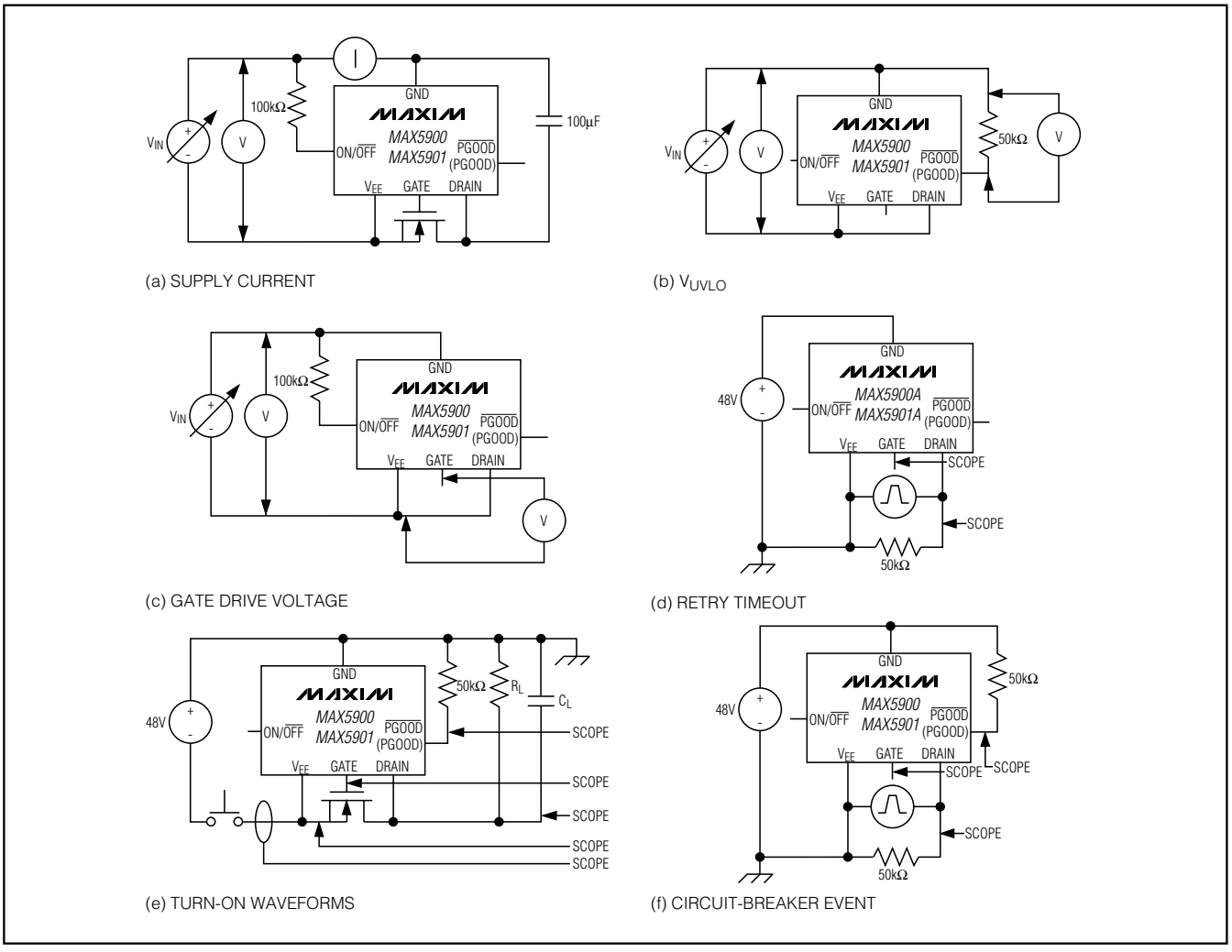


Figure 6. Test Circuits

-100V, SOT23/TDFN, Simple Swapper Hot-Swap Controllers

Selector Guide

SOT23

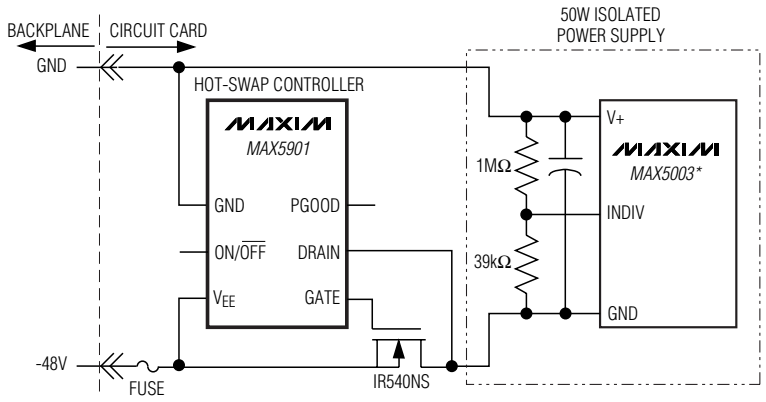
PART	CIRCUIT-BREAKER FUNCTION	CIRCUIT-BREAKER THRESHOLD (mV)	POWER-GOOD OUTPUT LOGIC	TOP MARK
MAX5900NNEUT+T	None	None	Active-Low	AAQV
MAX5900AAEUT+T	Autoretry	200	Active-Low	AAQJ
MAX5900ABEUT+T	Autoretry	300	Active-Low	AAQK
MAX5900ACEUT+T	Autoretry	400	Active-Low	AAQL
MAX5900LAEUT+T	Latched	200	Active-Low	AAQM
MAX5900LBEUT+T	Latched	300	Active-Low	AAQN
MAX5900LCEUT+T	Latched	400	Active-Low	AAQO
MAX5901NNEUT+T	None	None	Active-High	AAQW
MAX5901AAEUT+T	Autoretry	200	Active-High	AAQP
MAX5901ABEUT+T	Autoretry	300	Active-High	AAQQ
MAX5901ACEUT+T	Autoretry	400	Active-High	AAQR
MAX5901LAEUT+T	Latched	200	Active-High	AAQS
MAX5901LBEUT+T	Latched	300	Active-High	AAQT
MAX5901LCEUT+T	Latched	400	Active-High	AAQU

TDFN

PART	CIRCUIT-BREAKER FUNCTION	CIRCUIT-BREAKER THRESHOLD (mV)	POWER-GOOD OUTPUT LOGIC	TOP MARK
MAX5900NNETT+T	None	None	Active-Low	AJT
MAX5900AAETT+T	Autoretry	200	Active-Low	AJU
MAX5900ABETT+T	Autoretry	300	Active-Low	AJV
MAX5900ACETT+T	Autoretry	400	Active-Low	AJW
MAX5900LAETT+T	Latched	200	Active-Low	AJX
MAX5900LBETT+T	Latched	300	Active-Low	AJY
MAX5900LCETT+T	Latched	400	Active-Low	AJZ
MAX5901NNETT+T	None	None	Active-High	AKA
MAX5901AAETT+T	Autoretry	200	Active-High	AKB
MAX5901ABETT+T	Autoretry	300	Active-High	AKC
MAX5901ACETT+T	Autoretry	400	Active-High	AKD
MAX5901LAETT+T	Latched	200	Active-High	AKE
MAX5901LBETT+T	Latched	300	Active-High	AKF
MAX5901LCETT+T	Latched	400	Active-High	AKG

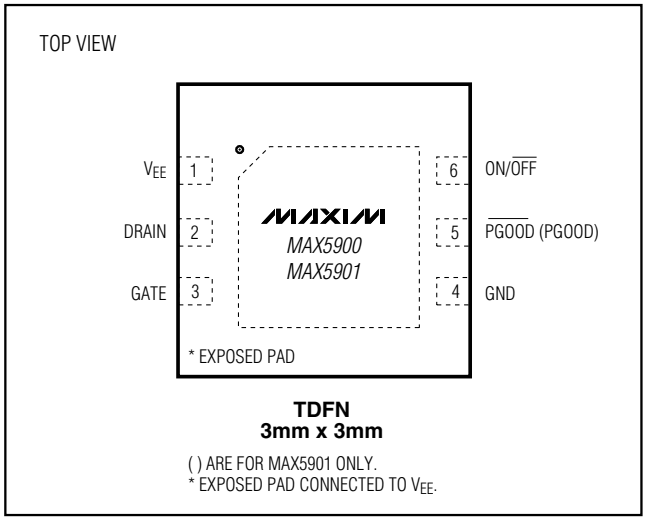
+Denotes lead-free package.

Typical Operating Circuits (continued)



*MAX5003 IS A 110V PWM CONTROLLER.

Pin Configurations (continued)



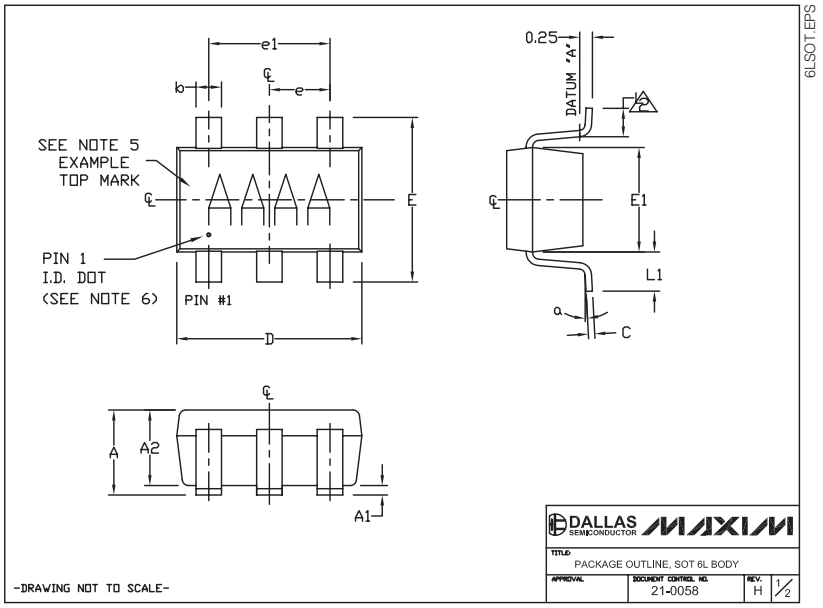
TDFN
3mm x 3mm

( ) ARE FOR MAX5901 ONLY.
* EXPOSED PAD CONNECTED TO V_{EE}.

-100V, SOT23/TDFN, Simple Swapper Hot-Swap Controllers

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**.)



NOTES:
1. ALL DIMENSIONS ARE IN MILLIMETERS.
2. FOOT LENGTH MEASURED AT INTERCEPT POINT BETWEEN DATUM A & LEAD SURFACE.
3. PACKAGE OUTLINE EXCLUSIVE OF MOLD FLASH & METAL BURR. MOLD FLASH, PROTRUSION OR METAL BURR SHOULD NOT EXCEED 0.25 MM.
4. PACKAGE OUTLINE INCLUSIVE OF SOLDER PLATING.
5. PIN 1 IS LOWER LEFT PIN WHEN READING TOP MARK FROM LEFT TO RIGHT. (SEE EXAMPLE TOP MARK)
6. PIN 1 I.D. DOT IS 0.3 MM ø MIN. LOCATED ABOVE PIN 1.
7. MEETS JEDEC MO178, VARIATION AB.
8. SOLDER THICKNESS MEASURED AT FLAT SECTION OF LEAD BETWEEN 0.08mm AND 0.15mm FROM LEADTIP.
9. LEAD TO BE COPLANAR WITHIN 0.1 MM.
10. NUMBER OF LEADS SHOWN ARE FOR REFERENCE ONLY.
11. MARKING IS FOR PACKAGE ORIENTATION REFERENCE ONLY.

SYMBOL	MIN	NOMINAL	MAX
A	0.90	1.25	1.45
A1	0.00	0.05	0.15
A2	0.90	1.10	1.30
b	0.35	0.40	0.50
C	0.08	0.15	0.20
D	2.80	2.90	3.00
E	2.60	2.80	3.00
E1	1.50	1.625	1.75
L	0.35	0.45	0.60
L1	0.60 REF.		
e1	1.90 BSC.		
e	0.95 BSC.		
a	0°	2.5°	10°

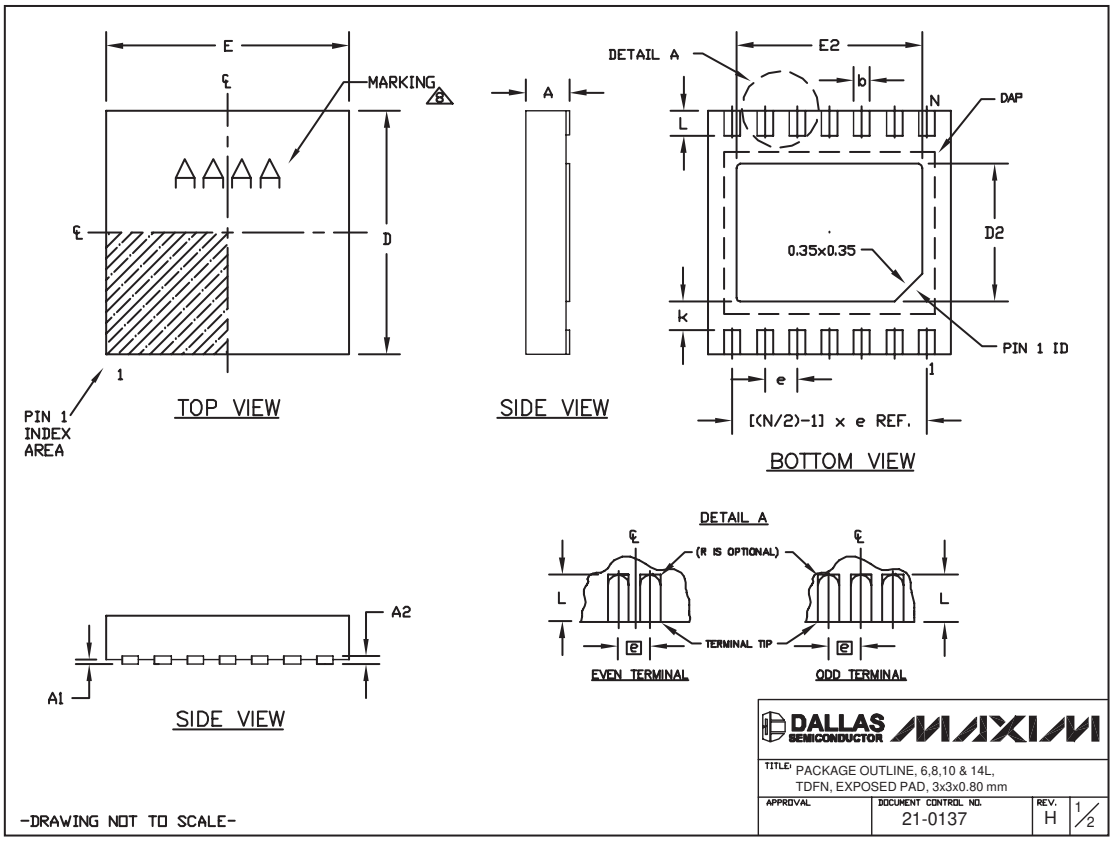
PKG CODES:
U6-1, U6-2, U6-4, U6C-8, U6CN-1, U6CN-2, U6S-3, U6F-5, U6F-6, U6FH-5, U6FH-6

-DRAWING NOT TO SCALE-
DALLAS SEMICONDUCTOR MAXIM
TITLE: PACKAGE OUTLINE, SOT 6L BODY
APPROVAL
DOCUMENT CONTROL NO. 21-0058
REV. H
2/2

-100V, SOT23/TDFN, Simple Swapper Hot-Swap Controllers

Package Information (continued)

(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**.)



-100V, SOT23/TDFN, Simple Swapper Hot-Swap Controllers

Package Information (continued)

(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**.)

COMMON DIMENSIONS		
SYMBOL	MIN.	MAX.
A	0.70	0.80
D	2.90	3.10
E	2.90	3.10
A1	0.00	0.05
L	0.20	0.40
k	0.25 MIN.	
A2	0.20 REF.	

PACKAGE VARIATIONS							
PKG. CODE	N	D2	E2	e	JEDEC SPEC	b	[(N/2)-1] x e
T633-1	6	1.50±0.10	2.30±0.10	0.95 BSC	MO229 / WEEA	0.40±0.05	1.90 REF
T633-2	6	1.50±0.10	2.30±0.10	0.95 BSC	MO229 / WEEA	0.40±0.05	1.90 REF
T833-1	8	1.50±0.10	2.30±0.10	0.65 BSC	MO229 / WEEC	0.30±0.05	1.95 REF
T833-2	8	1.50±0.10	2.30±0.10	0.65 BSC	MO229 / WEEC	0.30±0.05	1.95 REF
T833-3	8	1.50±0.10	2.30±0.10	0.65 BSC	MO229 / WEEC	0.30±0.05	1.95 REF
T1033-1	10	1.50±0.10	2.30±0.10	0.50 BSC	MO229 / WEED-3	0.25±0.05	2.00 REF
T1033-2	10	1.50±0.10	2.30±0.10	0.50 BSC	MO229 / WEED-3	0.25±0.05	2.00 REF
T1433-1	14	1.70±0.10	2.30±0.10	0.40 BSC	- - - -	0.20±0.05	2.40 REF
T1433-2	14	1.70±0.10	2.30±0.10	0.40 BSC	- - - -	0.20±0.05	2.40 REF

NOTES:
1. ALL DIMENSIONS ARE IN mm. ANGLES IN DEGREES.
2. COPLANARITY SHALL NOT EXCEED 0.08 mm.
3. WARPAGE SHALL NOT EXCEED 0.10 mm.
4. PACKAGE LENGTH/PACKAGE WIDTH ARE CONSIDERED AS SPECIAL CHARACTERISTIC(S).
5. DRAWING CONFORMS TO JEDEC MO229, EXCEPT DIMENSIONS "D2" AND "E2", AND T1433-1 & T1433-2.
6. "N" IS THE TOTAL NUMBER OF LEADS.
7. NUMBER OF LEADS SHOWN ARE FOR REFERENCE ONLY.
8. MARKING IS FOR PACKAGE ORIENTATION REFERENCE ONLY.

-DRAWING NOT TO SCALE-

DALLAS SEMICONDUCTOR MAXIM

TITLE: PACKAGE OUTLINE, 6,8,10 & 14L, TDFN, EXPOSED PAD, 3x3x0.80 mm

APPROVAL	DOCUMENT CONTROL NO.	REV.	
	21-0137	H	2/2

Revision History

Pages changed at Rev 5: 1–4, 10, 12–14

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