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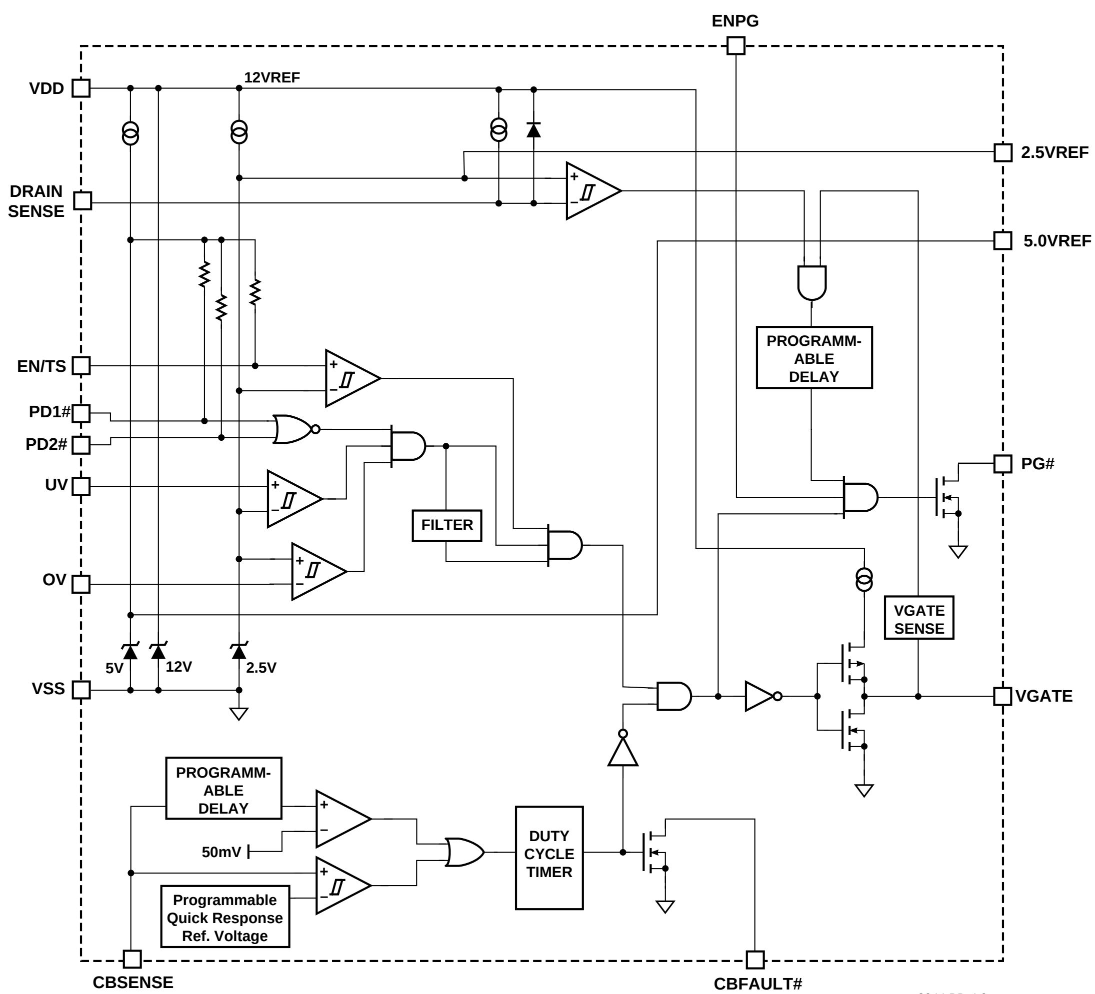
SMH4811A

Distributed Power Hot-Swap Controller

FEATURES

- Supply Range ±20VDC to >±500VDC
- Versatile Card Insertion Detection Supports:
  - Multi-length Pin Systems
  - Card Injector Switch Sensing
- Control Powering-on of DC/DC Converters
- Highly Programmable Host Voltage Monitoring
  - Programmable Under- and Over-voltage Detection
- Programmable Power Good Delay for enabling the DC/DC Converter
- Programmable Circuit Breaker Function
  - Programmable Over-current Filter
  - Programmable Quick-Trip™ Circuit Breaker Values
- 2.5V and 5.0V reference outputs
  - Easy Expansion of External Monitor Functions

FUNCTIONAL BLOCK DIAGRAM



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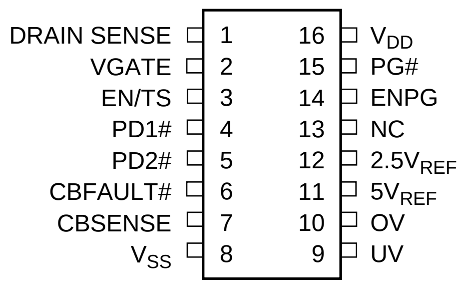
DESCRIPTION

The SMH4811A is designed to control hot swapping of plug-in cards operating from a single supply ranging from 20V to 500V. The SMH4811A hot-swap controller provides under-voltage and over-voltage monitoring of the host power supply, it drives an external power MOSFET switch that connects the supply to the load, and also protects against over-current conditions that might disrupt the host supply. When the input and output voltages to the SMH4811A controller are within specification, it provides a Power Good logic output that may be used to turn the loads on (*e.g.*, an isolated-output DC-DC converter, or drive a LED status light). Additional features of the SMH4811A include: temperature sense or master enable input, 2.5V and 5V reference outputs for expanding monitor functions, two Pin-Detect enable inputs for fault protection, and a duty-cycle over-current protection.

PIN CONFIGURATION

16-Pin SOIC



2044 SOIC PCon 4.0

ABSOLUTE MAXIMUM RATINGS*

Temperature Under Bias .... –55°C to 125°C
Storage Temperature .... –65°C to 150°C
Lead Solder Temperature (10 secs) .... 300 °C
Terminal Voltage with Respect to V_{SS}:

- V_{DD} .... –0.5V to V_{DD}
- OV, UV, DRAIN SENSE, CBSENSE .... –0.5V to V_{DD}+0.5V
- PD1#, PD2#, ENPG, EN/TS 10V
- CBFAULT, PG# ..... –0.5V to V_{DD}+0.5V
- VGATE .... V_{DD}+0.5V

*****COMMENT

Stresses 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 outside those listed in the operational sections of this specification is not implied. Exposure to any absolute maximum rating for extended periods may affect device performance and reliability.

DC OPERATING CHARACTERISTICS

(**Over Recommended Operating Conditions; Voltages are relative to** V_{SS})

Symbol	Parameter	Notes	Min.	Typ.	Max.	Units
V_{DD}	Supply voltage	I_{DD} = 2mA	11	12	13	V
$5V_{REF}$	Reference output	I_{DD} = 2mA	4.75	5.00	5.25	V
$5I_{LOAD}$	Reference output current	I_{DD} = 2mA	–1		1	mA
$2.5V_{REF}$	Reference output	I_{DD} = 2mA, T_A = 25ºC	2.475	2.500	2.525	V
		I_{DD} = 2mA	2.425	2.500	2.575	V
$2.5I_{LOAD}$	Reference output current	I_{DD} = 2mA	–0.2		1	mA
I_{DD}	Supply current	Output enabled	2		10	mA
V_{UV}	Under-voltage threshold	I_{DD} = 2mA, T_A = 25ºC	2.475	2.500	2.525	V
		I_{DD} = 2mA	2.425	2.500	2.575	V
V_{UVHYS}	Under-voltage hysteresis	I_{DD} = 2mA		10		mV
V_{OV}	Over-voltage threshold	I_{DD} = 2mA, T_A = 25ºC	2.475	2.500	2.525	V
		I_{DD} = 2mA	2.425	2.500	2.575	V
V_{UVHYS}	Over-voltage hysteresis	I_{DD} = 2mA		10		mV
V_{VGATE}	VGATE output voltage				V_{DD}	V
I_{VGATE}	VGATE output current			100		µA
V_{SENSE}	Drain sense threshold	I_{DD} = 2mA, T_A = 25ºC	2.475	2.500	2.525	V
		I_{DD} = 2mA	2.425	2.500	2.575	V
I_{SENSE}	Drain sense output current	V_{SENSE} = V_{SS}	9	10	11	µA
V_{CB}	Circuit breaker threshold	I_{DD} = 2mA	40	50	60	mV
V_{QCB}	Quick-trip circuit breaker threshold	Option E		200		mV
		Option F		100		mV
		Option H		50		mV
		Option J		Off		—
V_{ENTS}	EN/TS threshold	I_{DD} = 2mA, T_A = 25ºC	2.475	2.500	2.525	V
		I_{DD} = 2mA	2.425	2.500	2.575	V
$V_{ENTSHYS}$	EN/TS hysteresis	I_{DD} = 2mA	5	10	15	mV
V_{IH}	Input high voltage ENPG, CBRESET#		2		$5V_{REF}$	V
V_{IL}	Input high voltage ENPG		–0.1		0.8	V
V_{OL}	CBFAULT output low voltage	I_{OL} = 2mA	0		0.4	V
	PG output low	I_{SINK} = 2mA	0		0.4	V

2044 A Elect Table

AC Timing Characteristics, –40ºC. to 85ºC.

Symbol	Parameter	Notes	Min.	Typ.	Max.	Units
t_{PDD}	Pin detect delay to VGATE enable			80		ms
t_{CBD}	50mV circuit breaker delay	K		400		µs
		L		150		µs
		M		50		µs
		N		5		µs
P_{GD}	Power good delay	A		5		ms
		B		20		ms
		C		80		ms
		D		180		ms
$t_{FSTSHTDN}$	Fast shutdown delay from fault to VGATE off			200		ns
t_{CYC}	Circuit breaker cycle mode cycle time			1.5		s

2044 B Elect Table

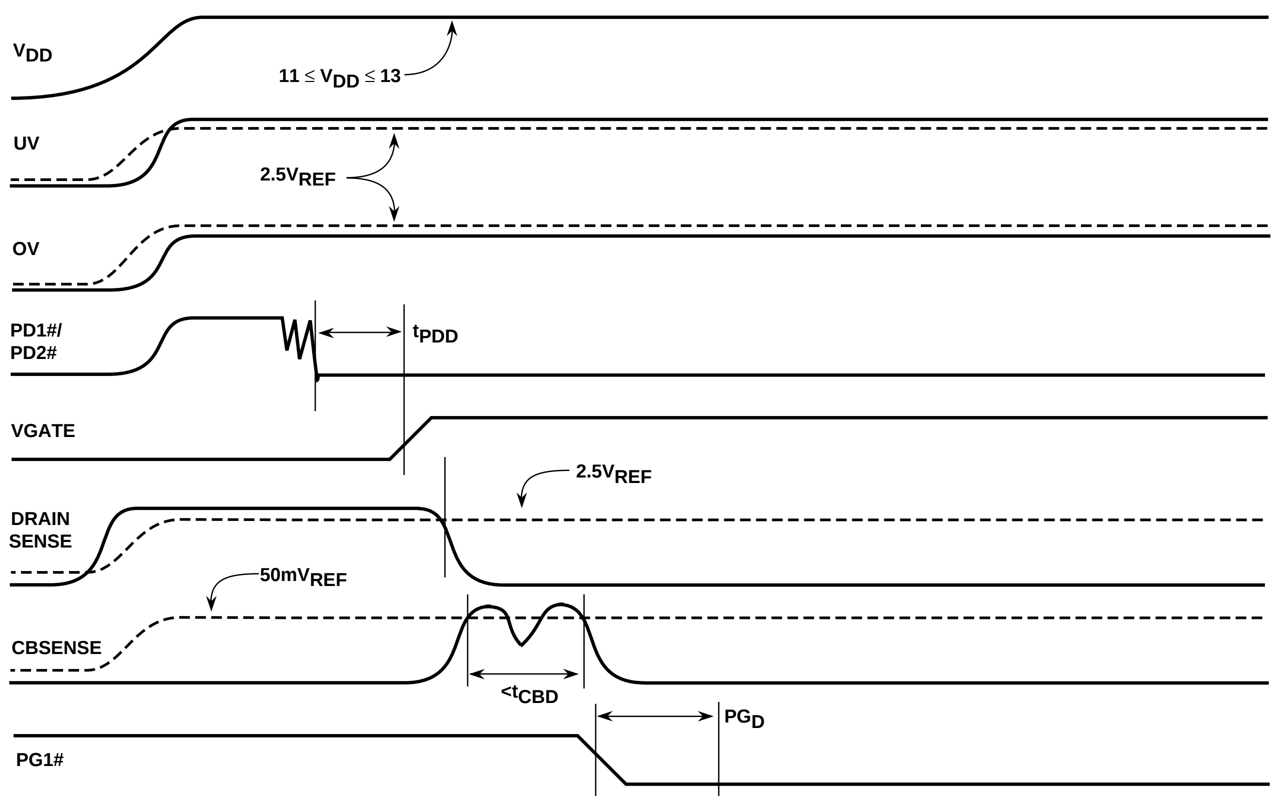


Figure 1. Power Sequencing Timing

PIN DESCRIPTIONS

V_{DD}

V_{DD} is the positive supply connection. An internal shunt regulator connected between V_{DD} and V_{SS} develops approximately 12V that supplies the SMH4804. A resistor must be placed in series with the V_{DD} pin to limit the regulator current (RD in the application illustrations).

V_{SS}

V_{SS} is connected to the negative side of the supply.

5VREF

5VREF is a precision 5V output reference voltage that may be use to expand the logic-input functions on the SMH4804. The reference output is with respect to V_{ss}.

2.5VREF

2.5VREF is a precision 2.5V output reference voltage that may be used to expand the logic-input functions on the SMH4804. The reference output is with respect to V_{SS}.

DRAIN SENSE

The DRAIN SENSE input monitors the voltage at the drain of the external power MOSFET switch with respect to V_{SS}. When the MOSFET is turned on the DRAIN SENSE input will be driven low and will be used as one of the enable conditions for the PG outputs. This will prevent any premature activation of the PG outputs.

CBSENSE

The circuit breaker sense input is used to detect over-current conditions in the load connected to the power MOSFET. A low value sense resistor (RS) is tied in series with the Power MOSFET; one end of the resistor is tied to V_{SS} and the other end is tied to the Power MOSFET and the CBSENSE input. A voltage drop of greater than 50mV (or greater than t_{CBD}) across the resistor will trip the circuit breaker. A programmable “quick-trip” sense point is also available. If the CBSENSE input transitions above the threshold the circuit breaker will immediately trip.

CBFAULT#

CBFAULT# is an open-drain, active-low output that indicates the circuit breaker status. When an over current condition is detected CBFAULT# is driven low.

EN/TS

The Enable/Temperature Sense input is the master enable input. When EN/TS is low VGATE, and the PG outputs are off. As the name suggests, the EN/TS input may be used as a master enable by a host system, or alternatively for circuit over-temperature protection using an external thermistor.

PD1#, PD2#

The PD1# and PD2# inputs are Pin Detect or auxiliary enable inputs that can optionally be employed by the designer. These are active low inputs and both inputs must be at V_{SS} before either VGATE or the PG outputs can be enabled.

In applications where multi-length connector pins are used the Pin Detect inputs should be tied to the shortest pins. On the mating connector side the pins opposite should be tied directly to V_{SS}. Alternatively, either one or both of the Pin Detect inputs can be tied to card injector handle switches, ensuring no power sequencing will occur until the card is properly seated.

OV and UV

The Under-Voltage and Over-Voltage input pins monitor the supply voltage for the SMH4804 and the downstream circuits. Both inputs have a default 2.5V threshold on their respective comparators. If UV is less than 2.5V, or if OV is greater than 2.5V, VGATE will be disabled.

Programmable internal hysteresis is provided on the Under-Voltage input and is adjusted in increments of 62.5mV. The adjustment is made in register R7.

VGATE

The VGATE output activates an external power MOSFET switch. It is a constant current source (100µA typical) allowing easy programming of the MOSFET turn on slew rate.

ENPG

The ENPG input controls the PG# output. When ENPG is pulled low the PG# output is immediately placed in a high impedance state. If ENPGA is driven high then the PG# output will immediately be driven low.

PG#

PG# is an open-drain, active-low output with no internal pull-up. It is enabled after VGATE is enabled and voltage across the load is within spec. PG# can be used to switch a load or enable a DC/DC converter.

PROGRAMMABLE FEATURES

Because the SMH4811A is electrically programmable it can be fine-tuned for a wide variety of applications prior to shipment to the customer. Because of this a manufacturer can use a common part type across a wide range of boards that are used on a common host but have different electrical loads, power-on timing requirements, host voltage monitoring needs, *etc.*

This ability to use a common solution across many platforms shifts the focus of design away from designing a new power interface for each board to concentrating on the value added back-end logic.

Because the programming of the features is done at final test all combinations (all 128 possibilities) are readily available as off the shelf stock items.

Power Good Delay

The PG delay timer that controls the delay from VGATE to PG# being asserted can be set to typical values of 5ms, 20ms, 80ms or 160ms.

Quick-Trip Circuit Breaker Threshold

The Quick-Trip circuit breaker threshold can be set to 200mV, 100mV, 60mv or Off. This is the threshold voltage drop across R_S that is placed between V_{SS} and CB-SENSE.

Circuit Breaker Delay

The circuit breaker delay defines the period of time the voltage drop across R_S is greater than 50mV but less than V_{QCB} before the VGATE output will be shut down. This is effectively a filter to prevent spurious shutdowns of VGATE. The delays that can be programmed are 5µs, 50µs, 150µs and 400µs.

Pin Detect

The Pin Detect function can be enabled or disabled.

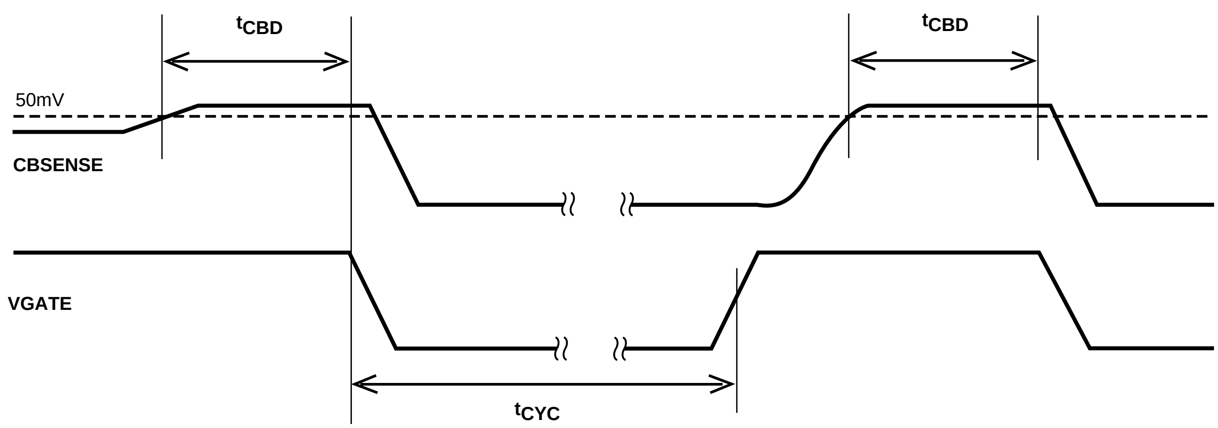


Figure 2. Circuit Breaker Timing

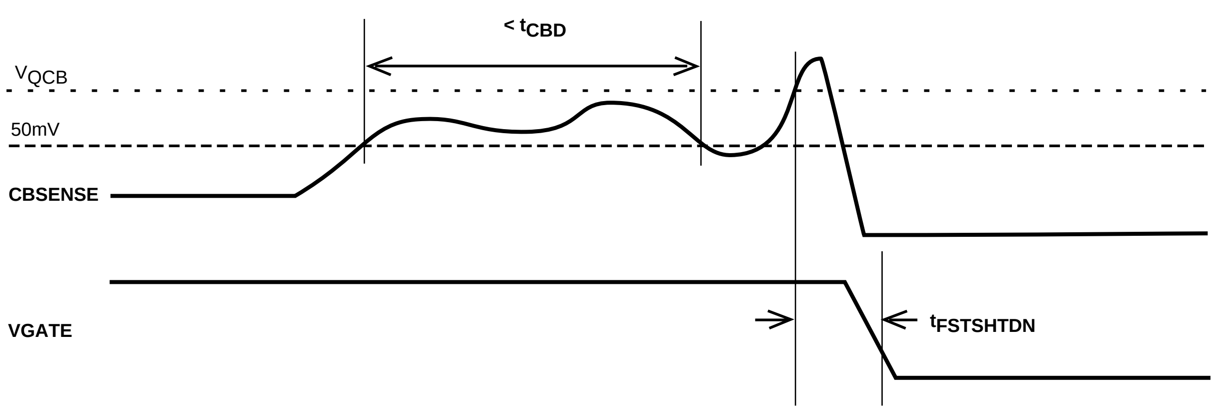


Figure 3. Circuit Breaker Timing — Quick Trip

DEVICE OPERATION

Power-Up Sequence

The SMH4811A is an integrated power controller for hot swappable add-in cards. The device operates from a single supply ranging from 20V to 500V and generates the signals necessary to drive isolated output DC/DC converters.

The SMH4811A hot-swap controller provides under-voltage and over-voltage monitoring of the host power supply, it drives an external power MOSFET switch that connects the supply to the load. It also protects against over-current conditions that might disrupt the host supply.

When the input and output voltages to the SMH4811A controller are within specification, the SMH4811A provides a "Power Good" logic output that may be used to turn ON a load or drive an LED status light. There is a master enable/temperature sense input and 2.5V and 5V reference outputs for expanding monitor functions.

Insertion Process

As the add-in board is inserted into the backplane, physical connections must be made with the chassis to discharge any electrostatic voltage potentials. The board then contacts the long pins on the backplane that provide power and ground. As soon as power is applied the SMH4811A starts up but does not immediately apply power to the output load. Under-voltage and over-voltage circuits inside the controller check to see if the input voltage is within a user-specified range, and pin detection signals determine whether the card is seated properly.

t_{PDD} after these requirements are met, the hot-swap controller enables V_{GATE} to turn on the power MOSFET switch. The V_{GATE} output is current limited to I_{VGATE}, allowing the slew rate to be easily modified using external passive components. During the controlled turn-on period, the V_{DS} of the MOSFET is monitored by the drain sense input. When V_{DS} drops below a user-specified voltage the power output is considered to be ON. The resistor and diode in series with the drain sense input determine $V_{DS}(ON)$.

Provided there is no sustained over-current condition during start-up, the SMH4811A turns on the loads with the Power Good logic outputs. Three DC/DC converters can be connected to the outputs and their turn-on is sequenced by pre-programmed delays. If a sustained over-current condition occurs during or after the insertion process, then V_{GATE} is shorted to V_{SS} and the MOSFET switch is turned off to protect the host supply.

Circuit Breaker Operation

The SMH4811A provides a circuit breaker function to protect against over current conditions. A sustained over-current event could damage the host supply and/or the load circuitry. The board's load current passes through a series resistor connected between MOSFET source/CB-Sense and Vss on the controller. The breaker will trip whenever the voltage drop across the series resistor is greater than 50mV for more than t_{CBD}, and will trip instantaneously if the voltage drop exceeds V_{QCB}.

When the breaker trips, the V_{GATE} output is turned off and CBFault# will be driven LO. In duty-cycle mode, the circuit breaker resets automatically after a fixed time period. If the over current condition still exists after reset, the circuit will re-trip. The MOSFET can be switched off by holding the CBReset input LO.

The value of the over-current sense resistor is determined by the following formula: $R_S = 50mV/I_{OC}$ where Rs is the value of the sense resistor and I_{OC} is the over current limit determined by the board's power requirement or the limit of the host supply.

Current Sense Resistors

Current sense resistors are available from a number of sources and come in two basic formats: open air sense resistors and current sense resistor chips. The open air resistors are metal strips that are available as both through-hole and surface mount. The resistor chips are surface mount and offer excellent thermal characteristics. Both styles are available in resistance ranges from 3mΩ to 1Ω.

IRC (www.irctt.com) is one source for these resistors. The open air sense resistors can be found in their OARS series, and the chip resistors are found in their LRC series.

Load Control

The SMH4811A is designed to control a single DC/DC converter, or other loads, which incorporate on/off control. The Power Good output activates the load when the following conditions have been met: the input voltage to the SMH4811A monitored by UV and OV is within user-defined limits and the external MOSFET is switched ON.

The delays built into the SMH4811A allow correct sequencing of power to the loads. The delay time is factory programmed.

The PG# output has a 12V withstand capability so high voltages must not be connected to this pin. Inexpensive bipolar transistors will boost the withstand voltage to that of the host supply, see figure 5 for connections.

Output Slew-Rate Control

The SMH4811A provides a current limited V_{GATE} turn-on. A fast turn-off is performed by internally shorting V_{GATE} to Vss. Changing the passive components around the power MOSFET switch will modify the turn-on slew-rate.

Operating at High Voltages

The breakdown voltage of the external active and passive components limits the maximum operating voltage of the SMH4811A hot-swap controller. Components that must be able to withstand the full supply voltage are: the input and output decoupling capacitors, the protection diode in series with the DRAIN SENSE pin, the power MOSFET switch and capacitor connected between its drain and gate, the high-voltage transistors connected to the power good outputs, and the dropper resistor connected to the controller's V_{DD} pin.

Over-Voltage and Under-Voltage Resistors

In the following examples, the three resistors, R1, R2, and R3, connected to the OV and UV inputs must be capable of withstanding the maximum supply voltage which can be several hundred volts. The trip voltage of the UV and OV inputs is +2.5V relative to Vss. As the input resistances of UV and OV are very high, large value resistors can be used in the resistive divider. The divider resistors should be high stability, 1% metal-film resistors to keep the under-voltage and over-voltage trip points accurate.

Telecom Design Example

A hot-swap telecom application uses a 48V power supply with a –25% to +50% tolerance, i.e. the 48V supply can vary from 36V to 72V. The formulae for calculating R1, R2, and R3 are shown below.

1) First select the peak current, ID_{MAX}, allowed through the resistive divider, say 250µA. The value of current is arbitrary; however, if the current is too high, self-heating in R3 may become a problem (especially in high voltage systems), and if the current is too low the value of R3 becomes very large and may be expensive at 1% tolerance.

R1 is calculated from:

$$R1 = \frac{V_{OV}}{ID_{MAX}}$$

V_{OV} is the over-voltage trip point, i.e. 2.5V, therefore:

$$R1 = \frac{2.5V}{250\mu A} = 10k\Omega$$

2) The minimum current that flows through the resistive divider, ID_{MIN}, is easily calculated from the ratio of maximum and minimum supply voltages:

$$ID_{MIN} = \frac{ID_{MAX} \times VS_{MIN}}{VS_{MAX}}$$

Therefore:

$$ID_{MIN} = \frac{250\mu A \times 36V}{72V} = 125\mu A$$

3) The value of R3 is now calculated using ID_{MIN}.

$$R3 = \frac{VS_{MIN} - V_{UV}}{ID_{MIN}}$$

Where V_{UV} is the under-voltage trip point, also 2.5V, therefore:

$$R3 = \frac{36V - 2.5V}{125\mu A} = 268k\Omega$$

The closest standard 1% resistor value is 267kΩ

4) R2 may be calculated using:

$$R1 + R2 = \frac{V_{UV}}{ID_{MIN}}$$

or

$$R2 = \left(\frac{V_{UV}}{ID_{MIN}}\right) - R1$$

so

$$R2 = \left(\frac{2.5V}{125\mu A}\right) - 10k\Omega = 10k\Omega$$

Dropper Resistor Selection

The SMH4811A is powered from the high-voltage supply via a dropper resistor, RD. The dropper resistor must provide the SMH4811A (and its loads) with sufficient operating current under minimum supply voltage conditions, but must not allow the maximum supply current to be exceeded under maximum supply voltage conditions.

The dropper resistor value is calculated from:

$$RD = \frac{VS_{MIN} - V_{DDMAX}}{I_{DD} + I_{LOAD}}$$

Where VS_{MIN} is the lowest operating supply voltage, V_{DDMAX} is the upper limit of the SMH4811A supply voltage, I_{DD} is minimum current required for the SMH4811A to operate, and I_{LOAD} is any additional load current from the 2.5V and 5V outputs and between V_{DD} and V_{SS}.

The min/max current limits are easily met using the dropper resistor except in circumstances where the input voltage may swing over a very wide range, *e.g.*, input varies between 20V and 100V. In these circumstances it may be necessary to add an 11V zener diode between V_{DD} and V_{SS} to handle the wide current range. The zener voltage should be below the nominal regulation voltage of the SMH4811A so that it becomes the primary regulator.

MOSFET V_{DS}(ON) Threshold

The drain sense input on the SMH4811A monitors the voltage at the drain of the external power MOSFET switch with respect to V_{SS}. When the MOSFET's V_{DS} is below the user-defined value the switch is considered to be ON. The V_{DS}(ON) is adjusted using the resistor R_T in series with the drain sense protection diode. This protection or blocking diode prevents high voltage breakdown of the drain sense input when the MOSFET switch is OFF. An inexpensive 1N4148 diode offers protection up to 75V. The V_{DS}(ON) threshold is calculated from:

$$V_{DS} = V_{SENSE} - (I_{SENSE} \times R_T) - V_{DIODE} - (I_{RS} \times R_S)$$

Where V_{DIODE} is the forward voltage drop of the protection diode, and I_{RS} is the current flowing through the circuit breaker sense resistor R_S. The V_{DS}(ON) threshold varies over temperature due to the temperature dependence of V_{DIODE}. Using 100kΩ for R_T gives an approximate V_{DS}(ON) threshold of:

$$V_{DS} = 2.5V - (10\mu A \times 100k\Omega) - 0.5V = 1V$$

APPLICATIONS CIRCUITS

Temperature Sensing

The 2.5V reference and 5V outputs on the SMH4811A make it easy to expand the enable or monitoring inputs. The circuit in Figure 4 illustrates how a low-voltage comparator is used to make an over-temperature detector. The comparator draws power from the 5V output on the SMH4811A and uses the 2.5V reference for the switching threshold. R6 is an NTC resistor that causes the SMH4811A to shut down when the maximum ambient temperature is exceeded. The temperature trip point is altered by changing R6 and/or R7. A 1MΩ resistor adds hysteresis around the comparator to prevent oscillation near the trip point.

Reversing Polarity of the Power Good Outputs

The open-drain Power Good outputs on the SMH4811A are active low. The output polarity may be changed to active high, when required, with a minor circuit change around the high-voltage buffer transistor. See Figure 5. The 1N4148 blocking diode must be included to prevent high-voltage damage to the SMH4811A.

Illustrations

Notes:

1. In Figures 4, 5, 6, and 7 the resistor RV must be physically located as close to the FET as possible.

2. The "Pin Detect" pins must be shorter than the other pins so that they do not make contact with the card connector until the card is well seated.

3. In Figure 4 the following values are used: R4 = 1kW, R5 = 1MW, R6 = NTC 50kW @ T_{MAX}, R7 = 50kW, U1 = LMV331. Formulas for determining these values appear in the previous section of the Data Sheet.

4. In Figure 6 the "On/Off" transistor must be physically close to the DC/DC converter.

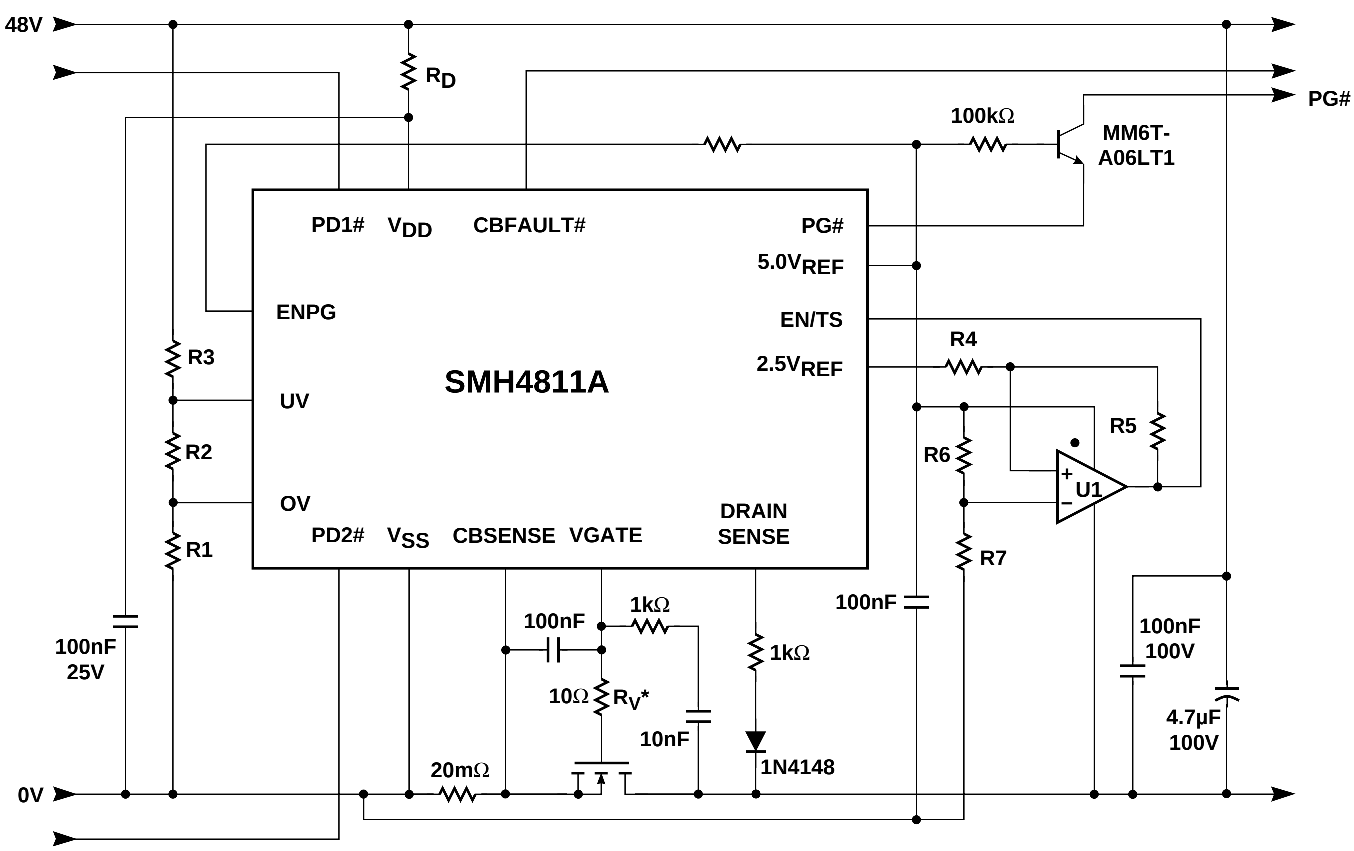


Figure 4. Basic Distributed Power Hot Swap Circuit

Figure 4

The 2.5Vref and 5Vref outputs are used to support the peripheral circuits. In this example ENPG is pulled high to the self-generated $5V_{REF}$.

The U1 circuitry is a temperature sensor that is effectively a safety shut down circuit tied into the EN/TS input. If the LMV331 drives its output low it will immediately turn off the V_{GATE} output.

The physical implementation of the board pins (see Note 2.) ensures the add-in card has power to the SMH4811, but power to the backend circuits cannot be turned on until the card is properly seated.

Figure 5

The polarity of the PG# output is reversed. EN/TS and ENPG are under the control of the host system.

Figure 6

A circuit for controlling a DC/DC converter with a remote off/on function. It should be noted the board layout for the DC/DC converters is critical for proper operation. Most manufacturers will have detailed technical notes to assist with this. An excellent note is "Application Guidelines for On-Board Power Converters" from Lucent Technologies.

Figure 7

A circuit for controlling a dual DC/DC converter with a remote off/on function.

> *Note: Pin detect inputs must be connected to the –48V input when the card is inserted, not to the 0V input.*

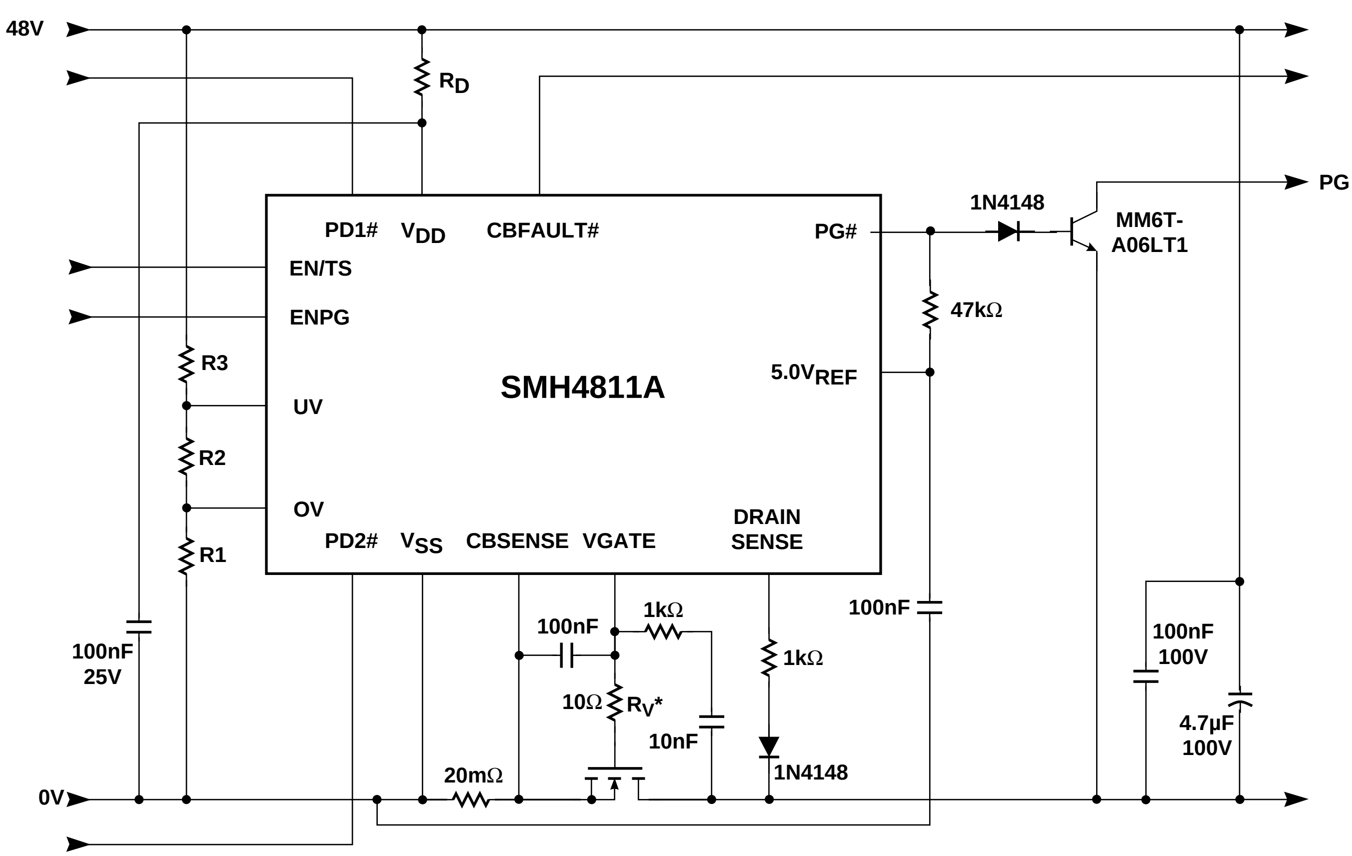


Figure 5. Generic Hot Swap implementation

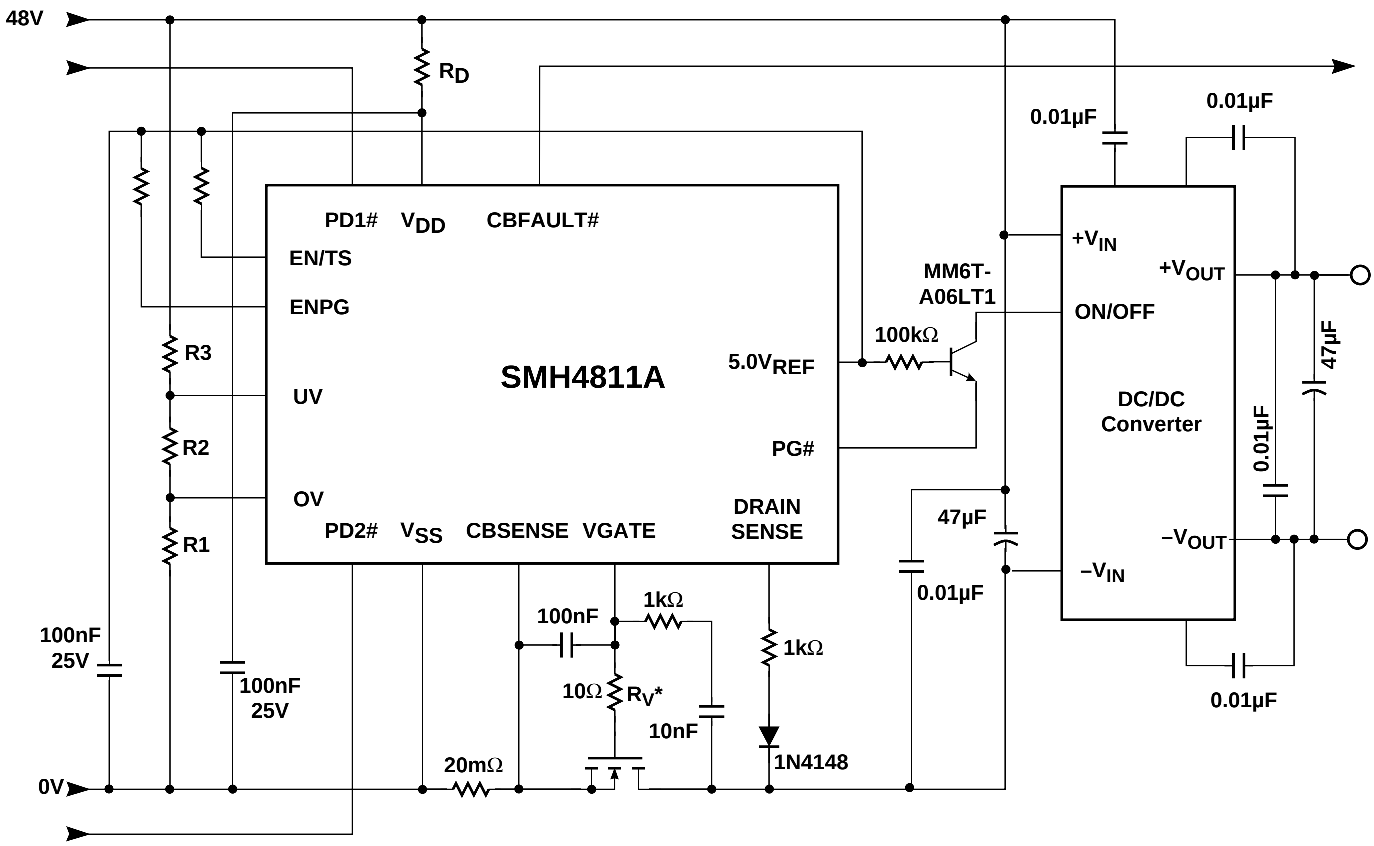


Figure 6. A Hot Swap Application for Controlling a DC/DC Converter

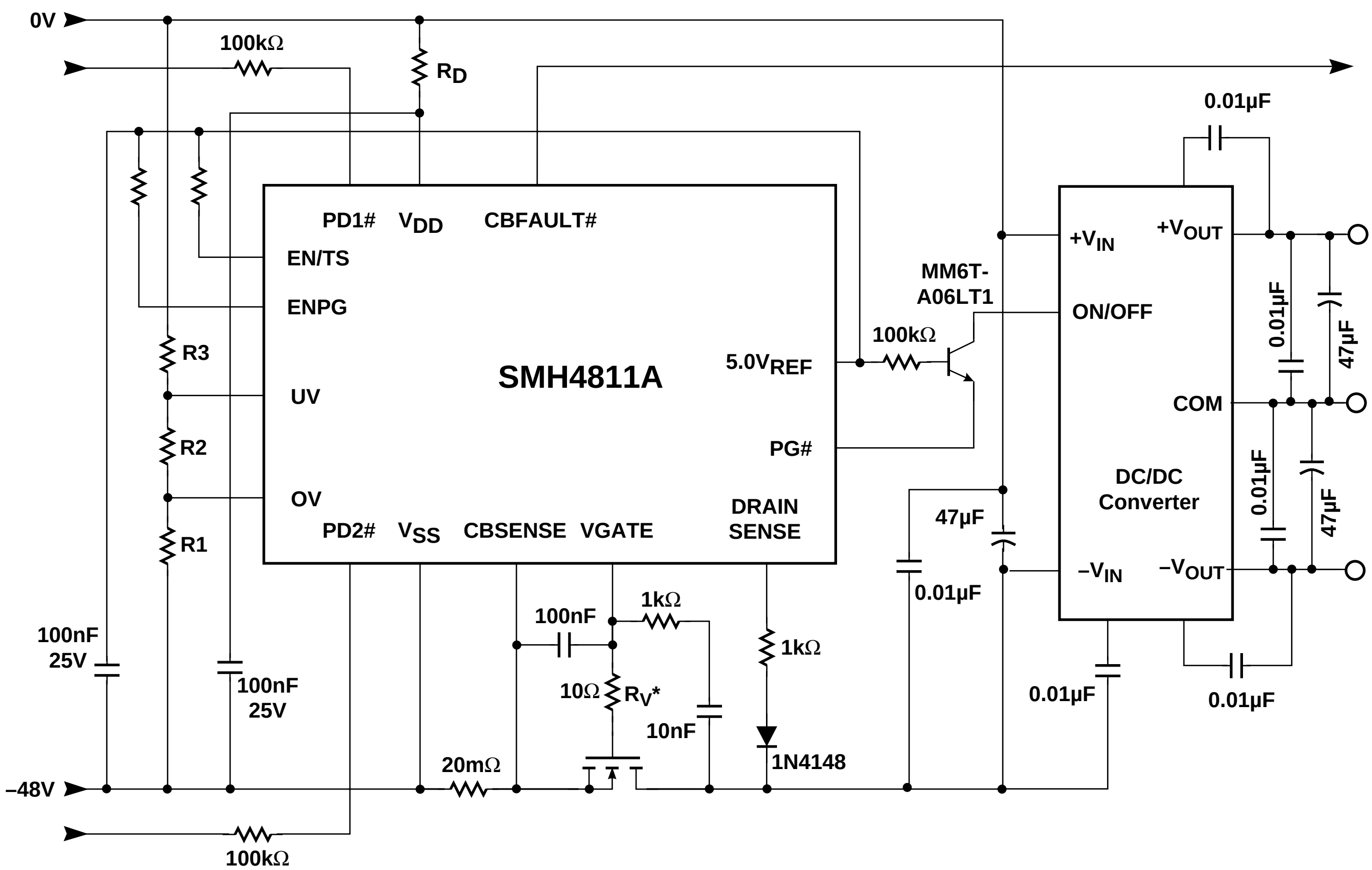
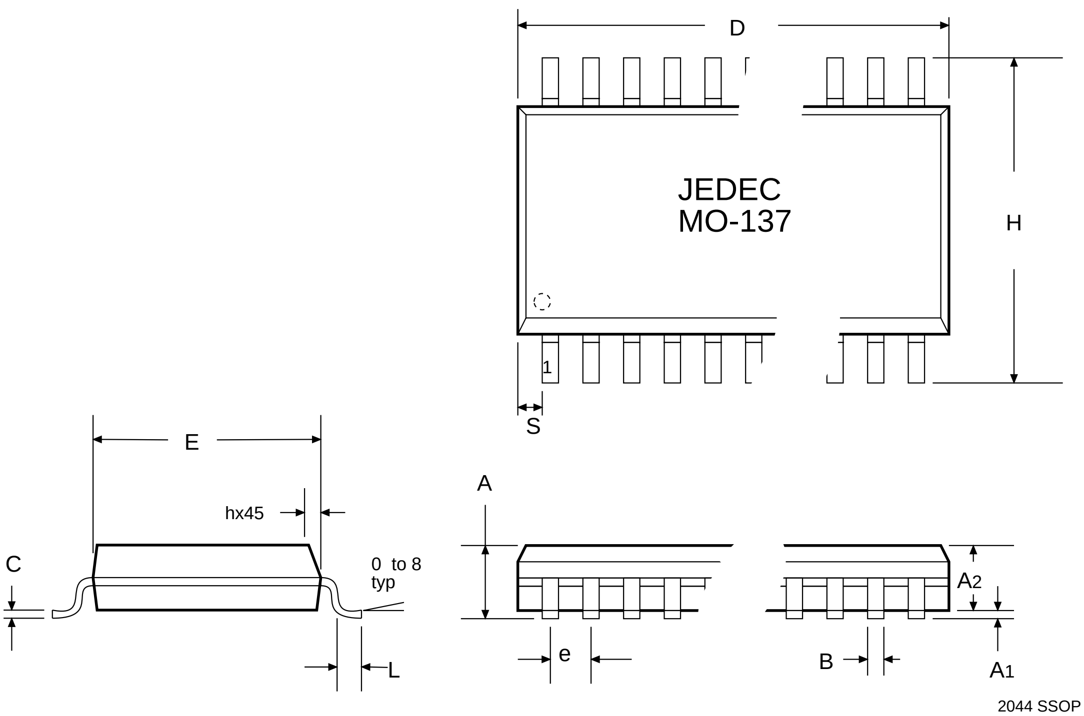


Figure 7. A Hot Swap Application for Controlling a dual DC/DC Converter

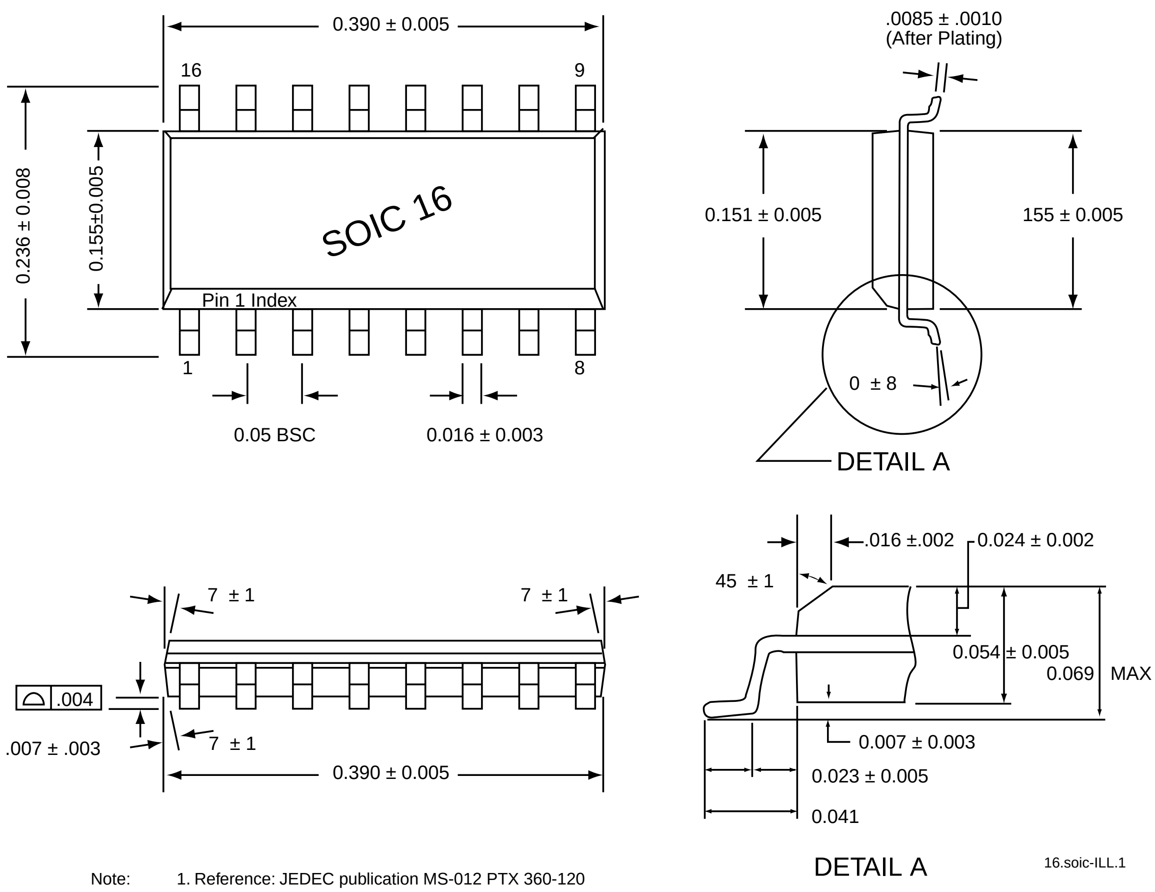
PACKAGES

SSOP PACKAGE



Dimension	Inches			Millimeters		
	Min.	Nom.	Max.	Min.	Nom.	Max.
A	0.061	0.064	0.068	1.55	1.63	1.73
A1	0.004	0.006	0.0098	0.12	0.15	0.25
A2	0.055	0.058	0.061	1.4	1.47	1.55
B	0.008	0.010	0.012	0.20	0.25	0.31
C	0.0075	0.008	0.0098	0.19	0.20	0.25
D	0.337	0.342	0.344	8.56	8.69	8.74
E	0.150	0.155	0.157	3.81	3.94	3.99
e	0.025BSC			0.635BSC		
H	0.230	0.236	0.244	5.84	5.99	6.20
h	0.010	0.013	0.016	0.25	0.33	0.41
L	0.016	0.025	0.035	0.41	0.64	0.89
S	0.0500	0.0525	0.0550	1.27	1.33	1.40

16 PIN SOIC PACKAGE



Note: 1. Reference: JEDEC publication MS-012 PTX 360-120
2. Unit: Inches
3. Mold flash, protrusion & gate burr shall not exceed 0.006 inch per side.

ORDERING INFORMATION

SMH4811A G A E K P

Base Part Number — SMH4811A

Package — G
G = SSOP
S = SOIC

Power Good Delay — A
A = 5ms
B = 20ms
C = 80ms
D = 160ms

Quick Trip Threshold — E
E = 200mV
F = 100mV
H = 60mV
J = OFF

Circuit Breaker Delay — K
K = 400µs
L = 150µs
M = 50µs
N = 5µs

Pin Detect Function — P
Blank = Enabled
P = Disabled

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