150A DC/DC µModule Regulator with PMBus Interface

FEATURES

- **High Efficiency at High Frequency**
  - **Up to 87.0% Efficiency at 1MHz, 54V_{IN} to 0.8V_{OUT}**
- **PMBus-Compliant I^2C Serial Interface**
  - **Monitor Voltage, Current, Temperature and Faults**
  - **Internal EEPROM Fault Log Record**
  - **Digitally Programmable Control Loop**
  - **Program Voltage, Current Limits, Soft-Start/Soft-Stop, Frequency, Synchronization and Phasing, Power-Good, Warnings and Faults**
- **Wide Input Voltage Range: 45V to 65V**
- **Output Voltage Range: 0.5V to 1.1V**
- **Optimized for 45V to 65V_{IN} to 0.8V_{OUT}**
- **±0.5% Maximum DC Output Error with Differential Remote Voltage Sense**
- **±3% Current Readback Accuracy**
- Parallel and Current Share Multiple µModule® ICs
- 22mm × 24mm × 6.7mm Surface Mount Package

DESCRIPTION

The LTP™8800-1A is a 150A step-down µModule regulator that provides microprocessor core voltage from 54V power distribution architecture. It features remote configurability and telemetry monitoring of power management parameters over PMBus—an open standard I^2C-based digital interface protocol. The LTP8800-1A is comprised of a programmable digital control system with precision mixed-signal circuitry, EEPROM, power MOSFETs, planar transformer, inductors, and supporting components. Its high level of integration minimizes component count and design time and maximizes flexibility and power density. The LTP8800-1A preserves high efficiency at high conversion ratios by utilizing a resonant switching architecture that eliminates high voltage switching losses.

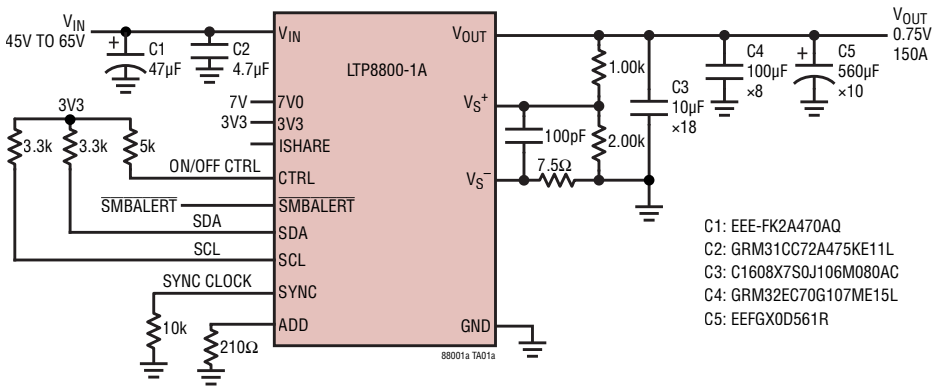
The LTP8800-1A is available in a 22mm × 24mm × 6.7mm surface-mounted open frame package.

APPLICATIONS

- High Current Distributed Power Systems
- Servers, Network, and Storage Equipment
- Intelligent Energy Efficient Power Regulation

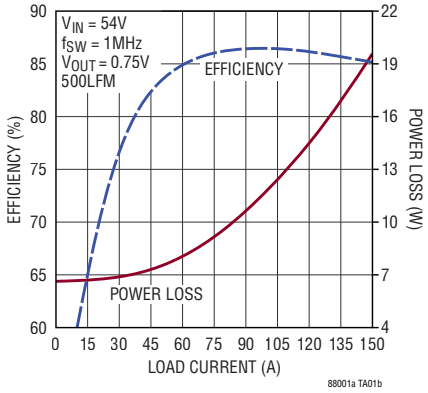
TYPICAL APPLICATION

54V to Core



C1: EEE-FK2A470AQ
C2: GRM31CC72A475KE11L
C3: C1608X7S0J106M080AC
C4: GRM32EC70G107ME15L
C5: EEFGX0D561R

Efficiency and Power Loss vs Output Current

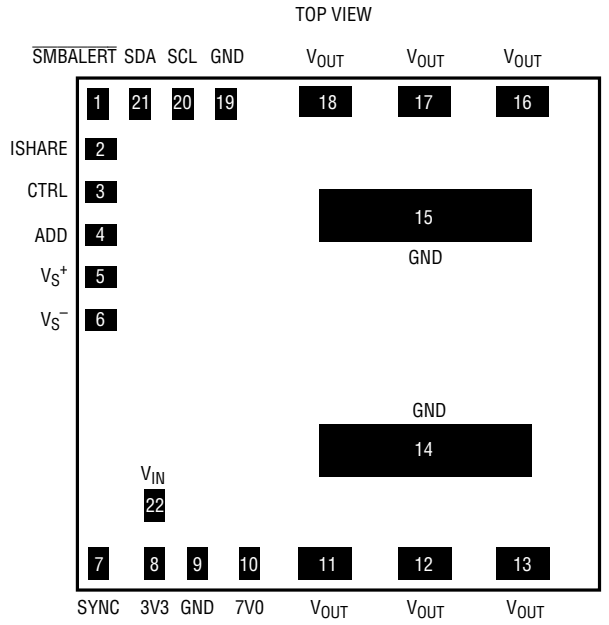


ABSOLUTE MAXIMUM RATINGS

(Note 1)

V_{IN} ..... –0.3V to 70V
7V0 ..... –0.3V to 7.75V
3V3, SYNC, CTRL, $\overline{SMBALERT}$, SDA, SCL, ISHARE, ADD ..... –0.3V to 3.6V
V_{OUT}, V_S^+ ..... –0.3V to 1.6V
V_S^- ..... –0.3V to 0.3V
Operating Junction Temperature Range
LTP8800-1A (Note 2) ..... 0°C to 125°C
Storage Temperature Range (Note 2)..... –40°C to 150°C
Peak Solder Reflow Body Temperature ..... 245°C

PIN CONFIGURATION



OPEN FRAME PACKAGE
22-LEAD (22mm × 24mm × 6.7mm)
WEIGHT = 9.5g

ORDER INFORMATION

PART NUMBER	PART MARKING	PACKAGE DESCRIPTION	MSL RATING	TEMPERATURE RANGE
LTP8800-1AIPV#PBF	LTP8800-1A	22-Pin (22mm × 24mm) Open Frame	3	0°C to 125°C

Contact the factory for parts specified with wider operating temperature ranges.

ELECTRICAL CHARACTERISTICS

The ● denotes the specifications which apply over the full operating temperature range, otherwise specifications are at T_A = 25°C.

SYMBOL	PARAMETER	CONDITIONS		MIN	TYP	MAX	UNITS
V_{IN} Supply							
V_{IN}	Input Operating Range		●	45		65	V
$V_{IN(UVLO)}$	Input Undervoltage	V_{IN} Rising		38	40	42	V
		V_{IN} Falling		36	38	40	V
$V_{IN(OVLO)}$	Input Overvoltage	V_{IN} Rising		68	70	73	V
		V_{IN} Falling		65	68	71	V

ELECTRICAL CHARACTERISTICS

The ● denotes the specifications which apply over the full operating temperature range, otherwise specifications are at T_A = 25°C.

SYMBOL	PARAMETER	CONDITIONS		MIN	TYP	MAX	UNITS
$I_{(VIN)}$	Input Standby Current	CTRL = 0V			0.1		mA
	Input Supply Current	I_{OUT} = 0A, V_{IN} = 54V, V_{OUT} = 0.80V			55		mA
		I_{OUT} = 10A, V_{IN} = 54V, V_{OUT} = 0.80V			0.22		A
		I_{OUT} = 150A, V_{IN} = 54V, V_{OUT} = 0.80V			2.53		A
7V0 Supply							
7V0	7V0 Operating Range		●	6.5	7	7.5	V
$7V0_{(UVLO)}$	7V0 Undervoltage	7V0 Rising	●			4.5	V
		7V0 Falling	●	3.5			V
I_{7V0}	7V0 Input Current		●		0.4	0.5	A
3V3 Supply							
3V3	3V3 Operating Range		●	3.0	3.3	3.6	V
$3V3_{(UVLO)}$	3V3 Undervoltage	3V3 Rising	●			3.0	V
		3V3 Falling	●	2.75			V
I_{3V3}	3V3 Input Current		●		60	70	mA
Output Specifications							
I_{OUT}	Output Current Range		●	0		150	A
$I_{OUT(MAX)}$	Output Current Limit				200		A
V_{OUT}	Regulated Output Voltage	I_{OUT} = 0A, V_{IN} = 54V, V_{OUT} Set to 0.800V, T_J = 25°C		0.796	0.800	0.804	V
		I_{OUT} = 0A, V_{IN} = 54V, V_{OUT} Set to 0.800V, T_J = 0°C to 125°C	●	0.788	0.800	0.812	V
$V_{OUT(LOAD+LINE)}$	Line + Load Regulation	I_{OUT} = 0A to 150A, V_{IN} = 45V to 65V	●	0.792	0.800	0.808	V
$V_{OUT(AC)}$	$V_{OUT(P-P)}$	V_{IN} = 54V, V_{OUT} = 0.8V, C_{OUT} = 800µF MLCC, 5.6mF POSCAP			4		mV
	$V_{OUT(RMS)}$	V_{IN} = 54V, V_{OUT} = 0.8V, C_{OUT} = 800µF MLCC, 5.6mF POSCAP			1.6		mV
t_{START}	Start Time	CTRL High to V_{OUT} = 0.8V			10		ms
t_{STOP}	Stop Time	CTRL Low to Output Disable			10		µs
$\Delta V_{OUT(LS)}$	Maximum Output Voltage Excursion for Dynamic Load Step	V_{IN} = 54V, V_{OUT} = 0.8V, I_{OUT} = 112.5A to 150A at 37.5A/µs, C_{OUT} = 800µF MLCC, 5.6mF POSCAP			20		mV
t_{SETTLE}	V_{OUT} Settling Time to 1%	V_{IN} = 54V, V_{OUT} = 0.8V, I_{OUT} = 112.5A to 150A at 37.5A/µs, C_{OUT} = 800µF MLCC, 5.6mF POSCAP			25		µs
Efficiency		V_{IN} = 54V, V_{OUT} = 0.8V, I_{OUT} = 37.5A			80.0		%
		V_{IN} = 54V, V_{OUT} = 0.8V, I_{OUT} = 75A			86.5		%
		V_{IN} = 54V, V_{OUT} = 0.8V, I_{OUT} = 112.5A			86.8		%
		V_{IN} = 54V, V_{OUT} = 0.8V, I_{OUT} = 150A			85.6		%
Oscillator							
f_{SW}	Switching Frequency	Switching Frequency Set to 1.00 MHz	●	0.97	1.00	1.03	MHz
f_{SYNC}	SYNC Range		●	0.93	1.0	1.06	MHz
PMBus Monitoring							
$I_{MON(OUT)}$	Output Current Monitor	V_{IN} = 54V, V_{OUT} = 0.8V, I_{OUT} = 150A	●		±3		%
$I_{MON(IN)}$	Input Current Monitor	V_{IN} = 54V, V_{OUT} = 0.8V, I_{OUT} = 150A	●		±5		%

ELECTRICAL CHARACTERISTICS

The ● denotes the specifications which apply over the full operating temperature range, otherwise specifications are at T_A = 25°C.

SYMBOL	PARAMETER	CONDITIONS		MIN	TYP	MAX	UNITS
V_{OUTMON}	Output Voltage Monitor	V_{IN} = 54V, V_{OUT} = 0.8V, I_{OUT} = 0A, T_J = 25°C			±0.5		%
		V_{IN} = 54V, V_{OUT} = 0.8V, I_{OUT} = 0A, T_J = 0°C to 125°C	●	–1.5		+1.5	%
V_{INMON}	Input Voltage Monitor	V_{IN} = 45V to 65V, V_{OUT} = 0.8V, I_{OUT} = 75A	●		±2		%
T_{MON}	Temp Monitor	V_{IN} = 54V, V_{OUT} = 0.8V, I_{OUT} = 75A	●		±10		°C
Leakage Current Digital Inputs (CTRL, SDA, SCL, SYNC)							
I_{DGTL}	Input Leakage Current	0V ≤ V_{PIN} ≤ 3.6V	●			10	µA
Control Section							
V_{S^-CM}	V_S^- Common Mode Range		●	–100		100	mV
V_{MRGN}	Output Voltage Margin Range			0.5		1.10	V
$V_{OUT(OVLO)}$	Output Overvoltage Protection				1.2		V
Digital Inputs (CTRL, SDA, SCL, SYNC)							
V_{IH}	Input High Threshold Voltage	V_{3V3} = 3.3V	●	2.1			V
V_{IL}	Input Low Threshold Voltage	V_{3V3} = 3.3V	●			0.8	V
Digital Outputs (SDA, $\overline{\text{SMBALERT}}$)							
V_{OL}	Output Low Voltage		●			0.6	V
PMBus Timing Characteristics (SDA, SCL)							
f_{SCL}	Serial Bus Frequency		●	10		400	kHz

Note 1: Stresses beyond those listed under Absolute Maximum Ratings may cause permanent damage to the device. Exposure to any Absolute Maximum Rating condition for extended periods may affect device reliability and lifetime.

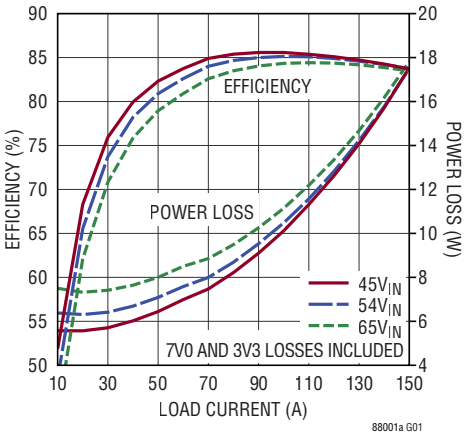
Note 2: The LTP8800-1AI is guaranteed over the full 0°C to 125°C operating junction temperature range. Operating lifetime is derated at junction temperatures greater than 125°C.

Note 3: The LTP8800-1AI includes overtemperature protection that is intended to protect the device during thermal overload conditions. Internal junction temperature may exceed 150°C if the overtemperature circuitry is active.

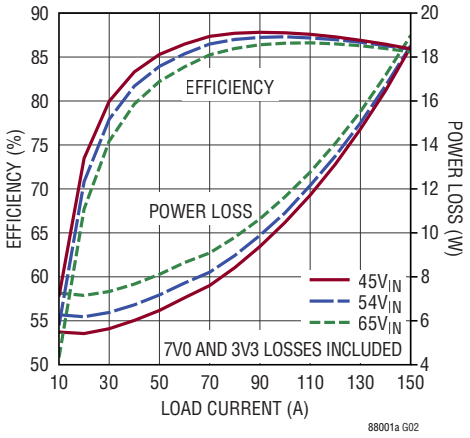
Note 4: All currents into device pins are positive; all currents out of device pins are negative. All voltages are referenced to ground unless otherwise specified.

TYPICAL PERFORMANCE CHARACTERISTICS

600mV$_{OUT}$ Efficiency and Power Loss vs Output Current

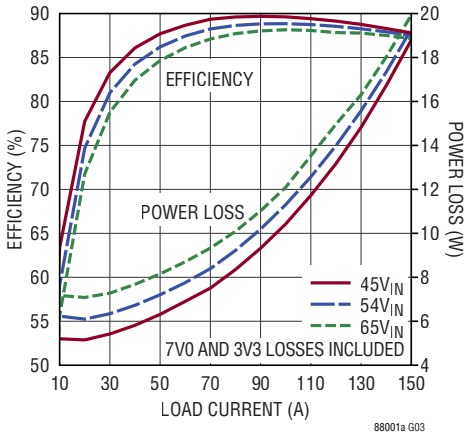


750mV$_{OUT}$ Efficiency and Power Loss vs Output Current



TYPICAL PERFORMANCE CHARACTERISTICS

900mV$_{OUT}$ Efficiency and Power Loss vs Output Current



Load Transient Response 112.5A to 150A Load Step 37.5A/µs 45V$_{IN}$ to 0.75V$_{OUT}$

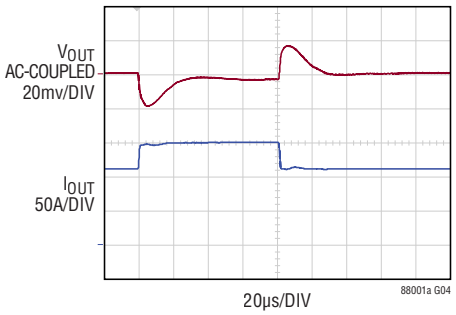
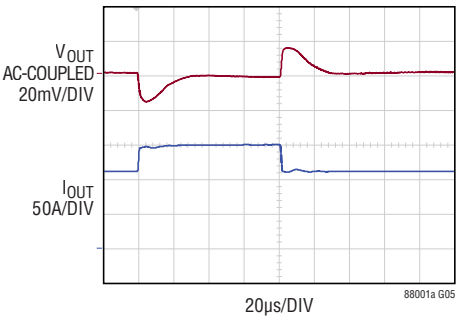


FIGURE 10 CIRCUIT
V_{IN} = 45V, V_{OUT} = 0.75V, f_{SW} = 1MHz
C_{OUT} = 560µF × 10 POSCAP + 100µF × 8 CERAMIC
REG FE01h = 24, REG FE02h = 223, REG FE03h = 72, REG FE04h = 149

Load Transient Response 112.5A to 150A Load Step 37.5A/µs 54V$_{IN}$ to 0.75V$_{OUT}$



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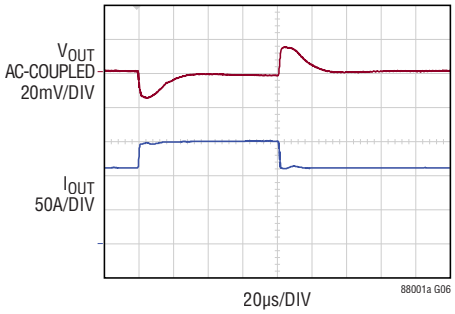
Load Transient Response 112.5A to 150A Load Step 37.5A/µs 65V$_{IN}$ to 0.75V$_{OUT}$



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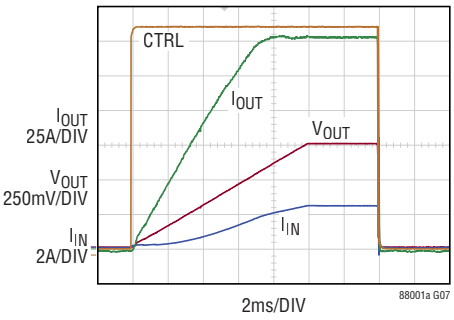
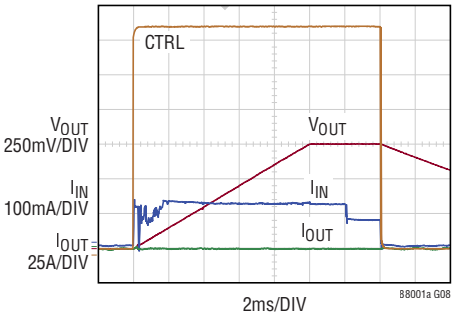
Full Load Start-Up and Shut-Down Triggered by CTRL



No Load Start-Up and Shut-Down Triggered by CTRL



45V$_{IN}$ No Load V$_{OUT}$ Ripple

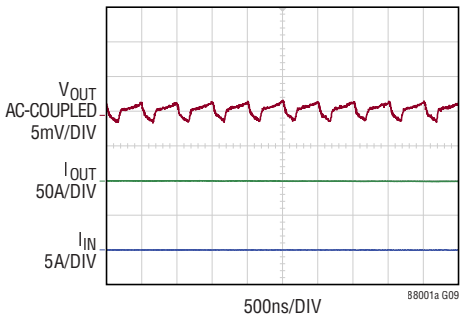


FIGURE 10 CIRCUIT
V_{IN} = 45V, V_{OUT} = 0.75V, f_{SW} = 1MHz
NO LOAD ON V_{OUT}

54V$_{IN}$ No Load V$_{OUT}$ Ripple

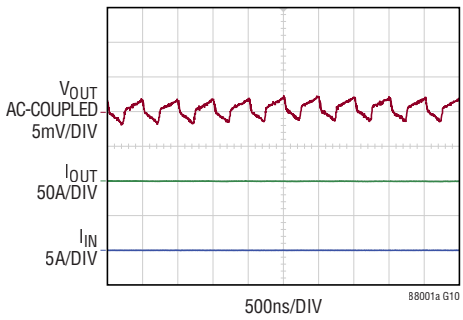


FIGURE 10 CIRCUIT
V_{IN} = 54V, V_{OUT} = 0.75V, f_{SW} = 1MHz
NO LOAD ON V_{OUT}

65V$_{IN}$ No Load V$_{OUT}$ Ripple

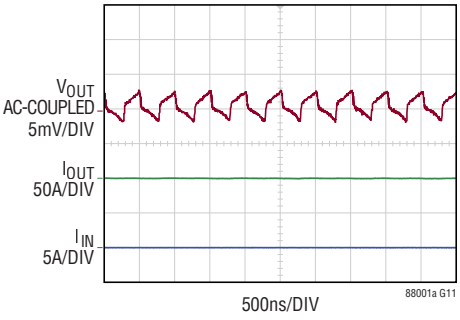


FIGURE 10 CIRCUIT
V_{IN} = 65V, V_{OUT} = 0.75V, f_{SW} = 1MHz
NO LOAD ON V_{OUT}

TYPICAL PERFORMANCE CHARACTERISTICS

45V_{IN} Full Load V_{OUT} Ripple

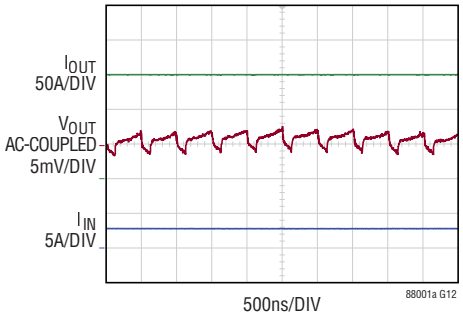
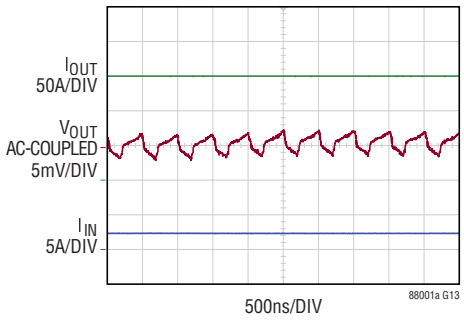


FIGURE 10 CIRCUIT
V_{IN} = 45V, V_{OUT} = 0.75V, f_{SW} = 1MHz
150A LOAD ON V_{OUT}

54V_{IN} Full Load V_{OUT} Ripple



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150A LOAD ON V_{OUT}

65V_{IN} Full Load V_{OUT} Ripple

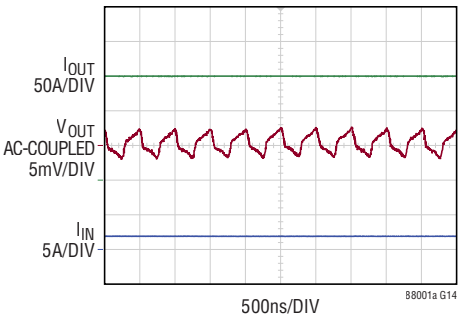
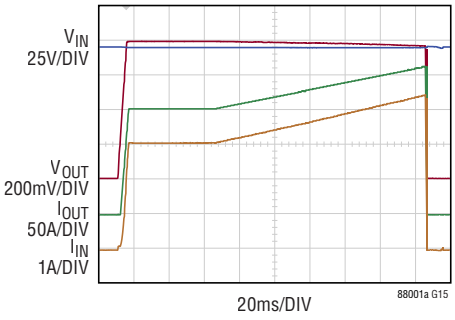
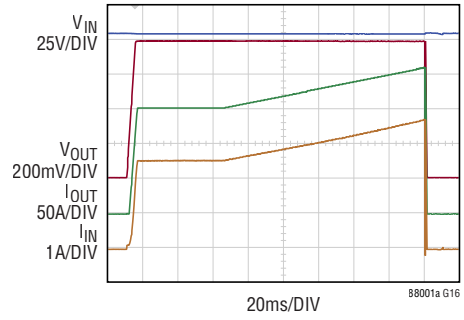


FIGURE 10 CIRCUIT
V_{IN} = 65V, V_{OUT} = 0.75V, f_{SW} = 1MHz
150A LOAD ON V_{OUT}

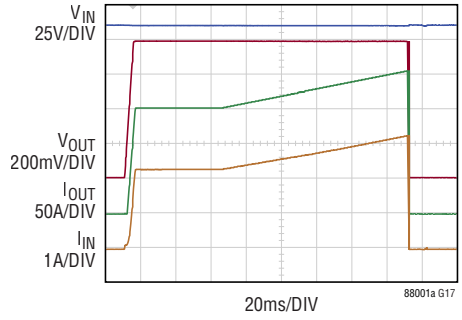
45V_{IN} OCP



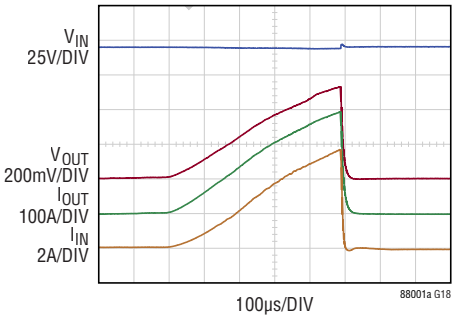
54V_{IN} OCP



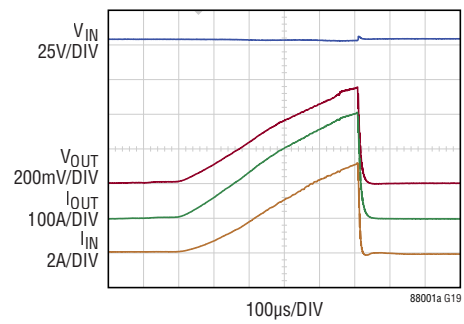
60V_{IN} OCP



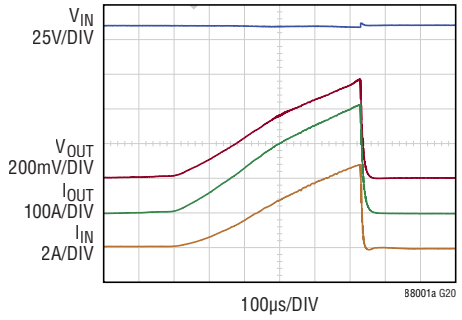
45V_{IN} Short-Circuit Start-Up



54V_{IN} Short-Circuit Start-Up



60V_{IN} Short-Circuit Start-Up



PIN FUNCTIONS

$\overline{\text{SMBALERT}}$ (Pin 1): Power-Good Output (Push-Pull). This pin is also used as the PMBus ALERT signal. If not used, pin should be left floating.

ISHARE (Pin 2): Analog Current Sharing Input and Output. This pin must connect to other µModule IC's ISHARE pins for current sharing. If not used, pin should be left floating.

CTRL (Pin 3): Power Supply ON Input. This pin performs hardware On/Off control. If this pin is not used, connect to 3V3.

ADD (Pin 4): I^2C/PMBus Address Select Input. Connect a resistor from ADD to GND. See the applications section for more information about the PMBus address selection.

V_S^+ (Pin 5): Noninverting Voltage Sense Input. This pin functions as the Kelvin sense of V_{OUT} at the load as well as the feedback point for the converter control loop. The V_S^+ pin can be directly tied to the load through a resistor or to a precision feedback resistor divider connected to the output voltage. The V_S^+ pin requires 100pF capacitance to the V_S^- pin placed close to the LTP8800-1A. The V_S^+ feedback resistors need to have a parallel resistance of <2k.

V_S^- (Pin 6): Inverting Voltage Sense Input. This pin functions as the Kelvin sense of GND at the load as well as the GND connection for the feedback point for the converter control loop.

SYNC (Pin 7): Synchronization Input Signal. This pin is used as a reference for the internal PWM frequency and is referenced to GND. Apply a 50% nominal duty-cycle clock input. If this pin is not used, connect to GND and program register 0xFE55 [6] = 1. The µModule is designed and programmed to operate at 1MHz from the factory. If using external SYNC do not deviate ±10% from 1MHz.

3V3 (Pin 8): The 3V3 pin powers internal µModule circuitry including the ADP1055 digital controller. Typical 3V3 supply current when operating is 60mA. This pin must be powered before the µModule can begin delivering power.

GND (Pins 9, 14, 15, 19): µModule Ground. The GND pins carry high current and must be connected to large planes with sufficient internal layers. Be sure to keep the voltage at the pins roughly equal by taking care of the direction of current flow and debiasing of the ground planes.

7V0 (Pin 10): The 7V0 pin powers internal µModule circuitry including gate drivers. The typical 7V0 supply current when operating is 0.4A. This pin must be powered before the µModule can begin delivering power.

V_{OUT} (Pins 11, 12, 13, 16, 17, 18): The V_{OUT} pins carry the high output current of the converter. As such, the pins must be connected to large power planes with sufficient internal layers. The PCB layout must be such that the two sets of V_{OUT} pins see roughly the same voltage. This ensures high efficiency and balanced currents. Output voltage is digitally programmable from 0.5V to 1.10V. V_{OUT} pins are two rows of terminals and carry high steady-state output currents (from 0A up to 150A) and transient currents up to 200A.

SCL (Pin 20): I^2C/PMBus Serial Clock Input and Output (Open-Drain).

SDA (Pin 21): I^2C/PMBus Serial Data Input and Output (Open-Drain).

V_{IN} (Pin 22): The V_{IN} pin supplies current to the primary power switches and operates from 54V/48V nominal inputs; for further details, see Absolute Maximum Ratings and Electrical Characteristics table for input voltage range. The LTP8800-1A requires 4µF of low ESR ceramic bypass capacitor; be sure to place the bypass capacitors as close to the µModule V_{IN} and GND as possible.

APPLICATIONS INFORMATION

COMPENSATION

The LTP8800-1A offers programmable loop compensation to optimize the transient response without any hardware change. A Type 3 filter architecture has been implemented. To tailor the loop response to the specific application, the low frequency gain, zero location, pole location and high frequency gain can all be set individually (see the Digital Filter Programming Registers section). From the sensed voltage to the duty cycle, the transfer function of the filter in z-domain is resolved by Equation 1.

$$H(z) = \left(\frac{D}{LFG} \bullet \frac{1}{(1 - z^{-1})} + \frac{C}{HFG} \frac{\left(1 - \frac{B}{256} z^{-1}\right)}{\left(1 - \frac{A}{256} z^{-1}\right)} \right) \quad (1)$$

Where:

A = filter pole register value (in decimal), 0xFE03.

B = filter zero register value (in decimal), 0xFE02.

C = high frequency gain register value (in decimal), 0xFE04.

D = low frequency gain register value (in decimal), 0xFE01.

$LFG = 9.5488 \times 10^7 / f_{SW}$.

$HFG = 5.968 \times 10^6 / f_{SW}$.

As shown in Figure 1, adjusting low frequency gain register value will change the gain of the compensation over the low frequency range without moving the pole and zero locations. Adjusting high frequency gain register value will change the gain of the compensation over the high frequency range without moving the pole and zero locations. As shown in Figure 2, adjusting the pole and zero register values will move the double poles and double zeroes of the compensation. Increasing the filter zero and pole register values will separate the double zeroes and double poles. It is recommended that LTpowerPlay® be used to program the filter.

It is recommended that the user determines the appropriate value for the compensation registers using the LTpowerCAD® tool. An example of the bode plot of the typical application circuit with the recommended compensation settings is shown in Figure 3. Measured bode plot of the LTP8800-1A in circuit Figure 10 with register setting (in decimal): 0xFE02 = 226, 0xFE03 = 160, 0xFE04 = 50, 0xFE01 = 8. (Crossover frequency: 28.84kHz, phase margin 64.5deg, gain margin 17.31dB).

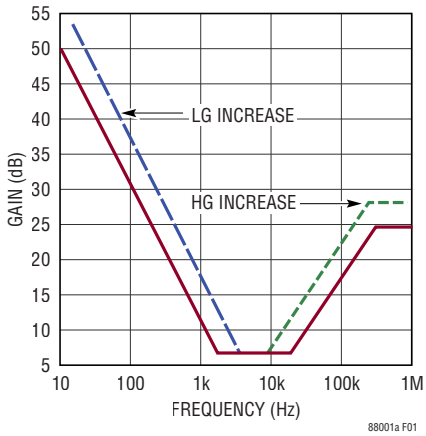


Figure 1. Compensation Gain Adjustment

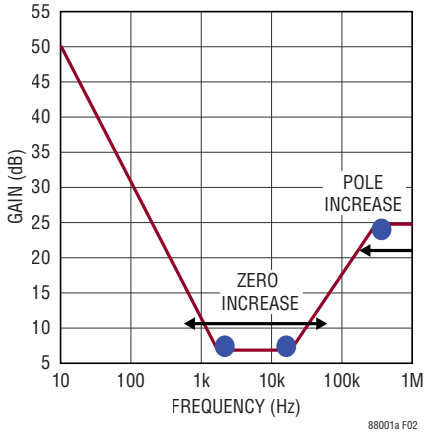


Figure 2. Compensation Poles and Zeroes Adjustment

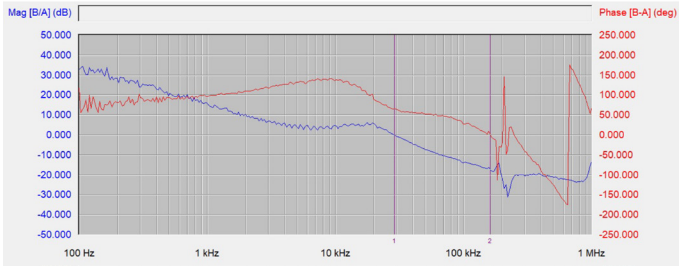


Figure 3. Measured Bode Plot of the LTP8800-1A

APPLICATIONS INFORMATION

PolyPhase CONFIGURATION

When configuring a PolyPhase® rail with multiple LTP8800-1A, the user must share the SYNC and ISHARE pins. An external clock source at the desired switching frequency is required for current sharing applications. The internal digital phase-locked loop is capable of determine the frequency on the SYNC pin and locking the internal switching frequency to the external frequency. The lock or capture range is ±10% of the switching frequency (Register 0x33). The relative phasing of all the channels should be spaced equally. This can be configured using Register 0x37. A phase shift in steps of 22.5 degree can be added.

PolyPhase LOAD SHARING

Multiple LTP8800-1A can be arrayed in order to provide a balanced load-share solution by bussing the ISHARE pins. Figure 4 illustrates a 2-phase design sharing connections required for load sharing.

PMBus COMMANDS AND LTPOWERPLAY

PMBus Commands

There are multiple PMBus commands and manufacturer specific commands, which can be customized to adjust the settings of LTP8800-1A µModule, as listed in Table 1. These commands comply to the PMBus Power System Management Protocol. Users are encouraged to refer to the PMBus Communication and Command Processing section for details.

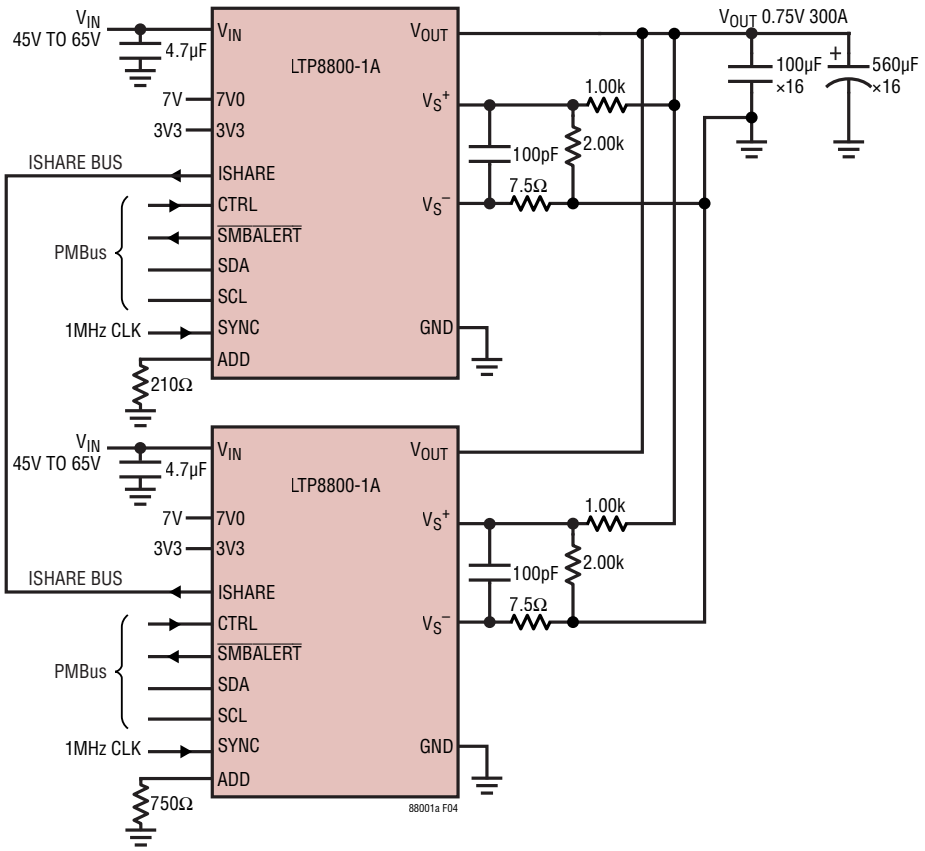


Figure 4. 2-Phase Operation Producing 0.75V at 300A

APPLICATIONS INFORMATION

Table 1. LTP8800-1A Summary of Customizable Commands and Features

PMBus COMMAND NAME, OR FEATURE	CMD CODE REGISTER	COMMAND OR FEATURE DESCRIPTION	TYPE	DATA UNITS	DATA FORMAT	NVM ATTRIBUTES
WRITE_PROTECT	0x10	Protect the PMBus device against accidental writes.	R/W Byte	NA	Bit Field	Stored in user-editable NVM.
VIN_ON	0x35	Sets the value of the input voltage (V_{RMS}) at which the device starts power conversion.	R/W Word	Volts	Linear 11	Stored in user-editable NVM.
VIN_OFF	0x36	Sets the value of the input voltage (V_{RMS}) at which the device stops power conversion.	R/W word	Volts	Linear 11	Stored in user-editable NVM.
VIN_OV_FAULT_LIMIT	0x55	Sets the upper voltage threshold (in volts) measured at the sense/input pin that causes an overvoltage fault condition.	R/W Word	Volts	Linear 11	Stored in user-editable NVM.
VIN_UV_FAULT_LIMIT	0x59	Sets the lower voltage threshold (in volts) measured at the sense/input pin that causes an undervoltage fault condition.	R/W Word	Volts	Linear 11	Stored in user-editable NVM.
IIN_OC_FAULT_LIMIT	0x5B	Sets the threshold value (in amperes) measured at the sense/input pin that causes an overcurrent fault condition.	R/W Word	Amps	Linear 11	Stored in user-editable NVM.
POUT_OP_FAULT_LIMIT	0x68	Sets the upper power threshold (in watts) measured at the sense/output pin that causes an output overpower fault condition.	R/W Word	Watts	Linear 11	Stored in user-editable NVM.
NM_DIGFILT_LF_GAIN_SETTING	0xFE01	Determines the low frequency gain of the loop response in normal mode.	R/W Byte	NA	NA	Stored in user-editable NVM.
NM_DIGFILT_ZERO_SETTING	0xFE02	Determines the position of the final zero in normal mode.	R/W Byte	NA	NA	Stored in user-editable NVM.
NM_DIGFILT_POLE_SETTING	0xFE03	Determines the position of the final pole in normal mode.	R/W Byte	NA	NA	Stored in user-editable NVM.
NM_DIGFILT_HF_GAIN_SETTING	0xFE04	Determines the high frequency gain of the loop response in normal mode.	R/W Byte	NA	NA	Stored in user-editable NVM.

APPLICATIONS INFORMATION

LTpowerPlay: AN INTERACTIVE GUI FOR DIGITAL POWER µModule ICs

LTpowerPlay is a powerful Graphical User Interface (GUI) that supports the digital power µModule LTP8800-1A, as shown in Figure 5. In online mode, LTpowerPlay can be used to evaluate single or multiple LTP8800-1A power µModule ICs of different types by connecting to a demo board or the user application. In offline mode with no hardware connected via PMBus, LTpowerPlay can also be used to build the project file with configuration of multiple µModule ICs, and the project file can be saved and reloaded later. Moreover, during board bring-up, LTpowerPlay can be used as a valuable diagnostic tool to program the power system, to tweak the system settings, or to diagnose system issues.

LTpowerPlay utilizes Analog Device's USB-to-I²C/SMBus/PMBus Controller, DC1613A, to communicate with circuit boards including the DC3198A (single LTP8800-1A µModule) or DC3176A (triple LTP8800-1A µModule ICs) demo boards, or a customer target system. Further context information, including tutorial demos, is available here.

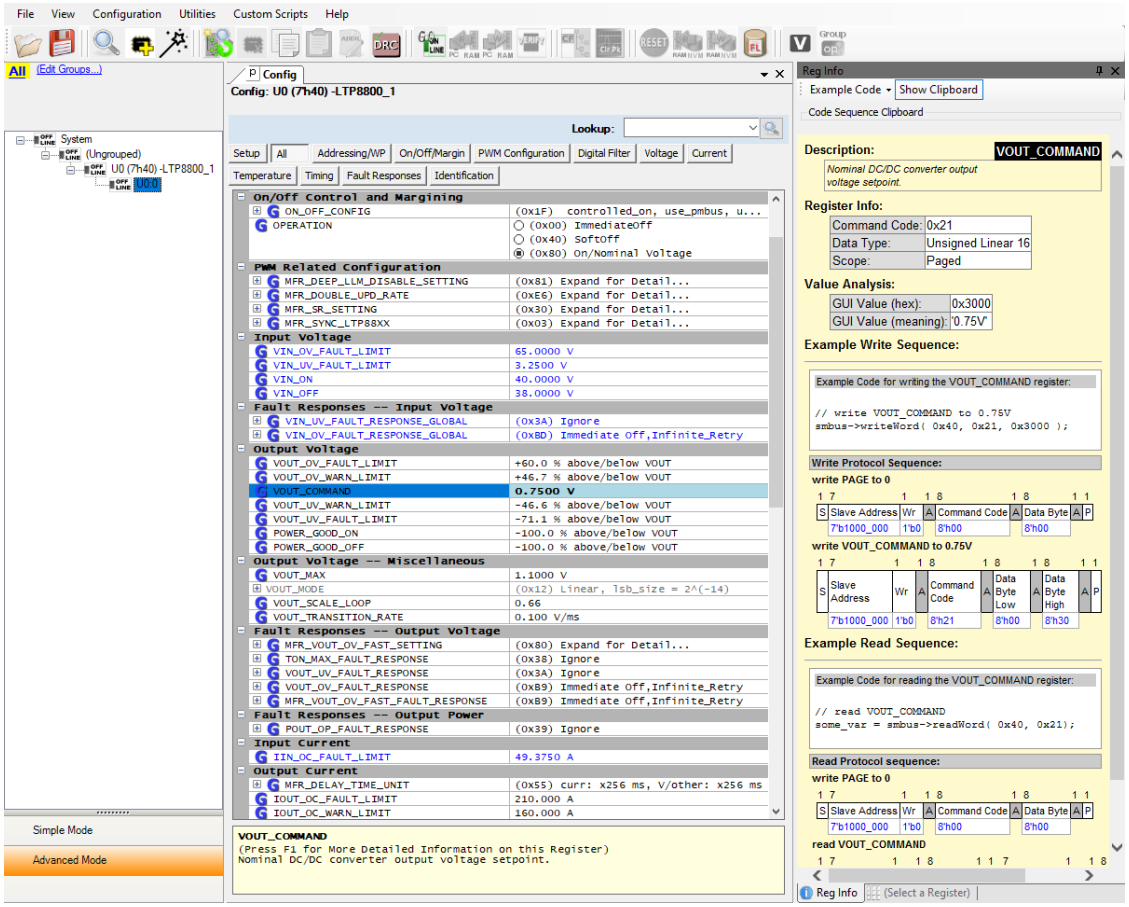


Figure 5. LTpowerPlay Main Interface

APPLICATIONS INFORMATION

PMBus COMMUNICATION AND COMMAND PROCESSING

The LTP8800-1A series communicate through PMBus with other compliant devices. The LTP8800-1A is always configured as a subordinate device in the overall system, requiring a two-wire interface with one data pin (SDA) and one clock pin (SCL). As subordinate devices, LTP8800-1A power µModule ICs decode the command sent from the main device and respond accordingly. Data transfer of the PMBus subordinate is based on PMBus commands. According to the PMBus/SMBus/I^2C communication protocol, all PMBus commands start with a subordinate address with the R/W bit cleared (set to 0), followed by the command code, with mostly the stop bit as the last bit in a complete data transfer.

Commands can be categorized as send, read, or write types. For read or write commands, data is transferred between devices in a byte wide format. For send commands, the subordinate device execute the commands upon receiving the stop bit. To ensure robust communication, the main and subordinate devices send acknowledge (ACK) or no acknowledge (NACK) bits as a method of handshaking, eliminating the busy errors between devices.

Manufacturer-specific extended commands are also supported by LTP8800-1A. These commands follow the same protocol as the standard PMBus commands. However, the command code consists of two bytes: Command code extension (0xFE) and Extended command code (0x00 to 0xFF). By use of the manufacturer-specific extended commands, the PMBus command set is greatly extended. The detailed information of standard PMBus and manufacturer-specific commands can be found in the ADP1055 data sheet.

PMBus ADDRESS SELECTION

The PMBus address is set by connecting an external resistor from the ADD pin to GND. Table 2 lists the recommended resistor values and associated PMBus addresses.

Table 2. Recommended Resistor Values and Associated PMBus Addresses

PMBus ADDRESS	1% RESISTOR ON ADD PIN (Ω)
0x40	210 (or Connect to GND)
0x41	750
0x42	1330
0x43	2050
0x44	2670
0x45	3570
0x46	4420
0x47	5360
0x48	6340
0x49	7320
0x4A	8450
0x4B	9530
0x4C	10,700
0x4D	12,100
0x4E	13,700
0x4F	15,000 (or Connect to 3V3)

APPLICATIONS INFORMATION

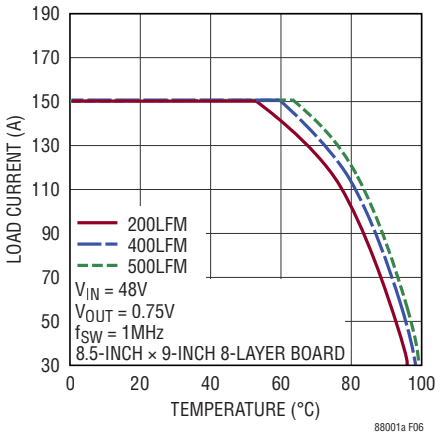


Figure 6. Thermal Derating $48V_{IN}$, $0.75V_{OUT}$

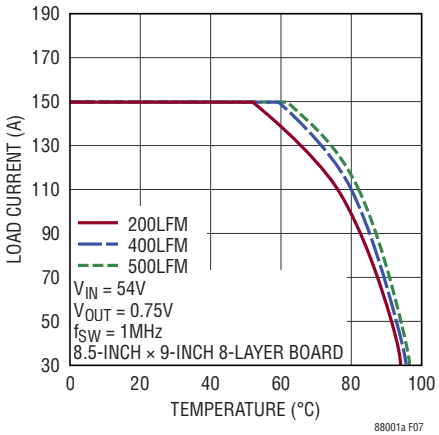
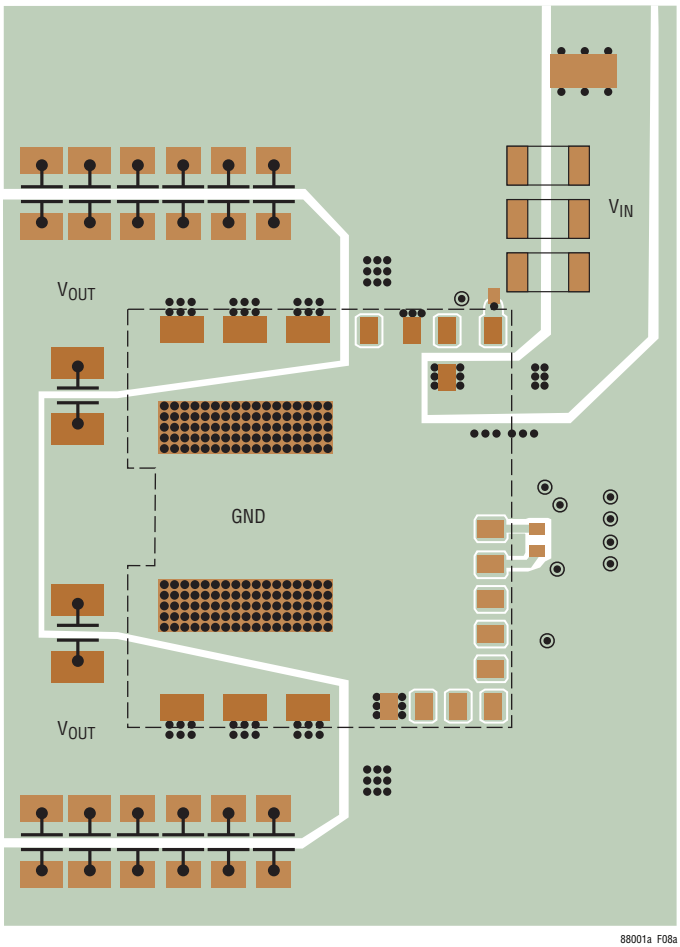
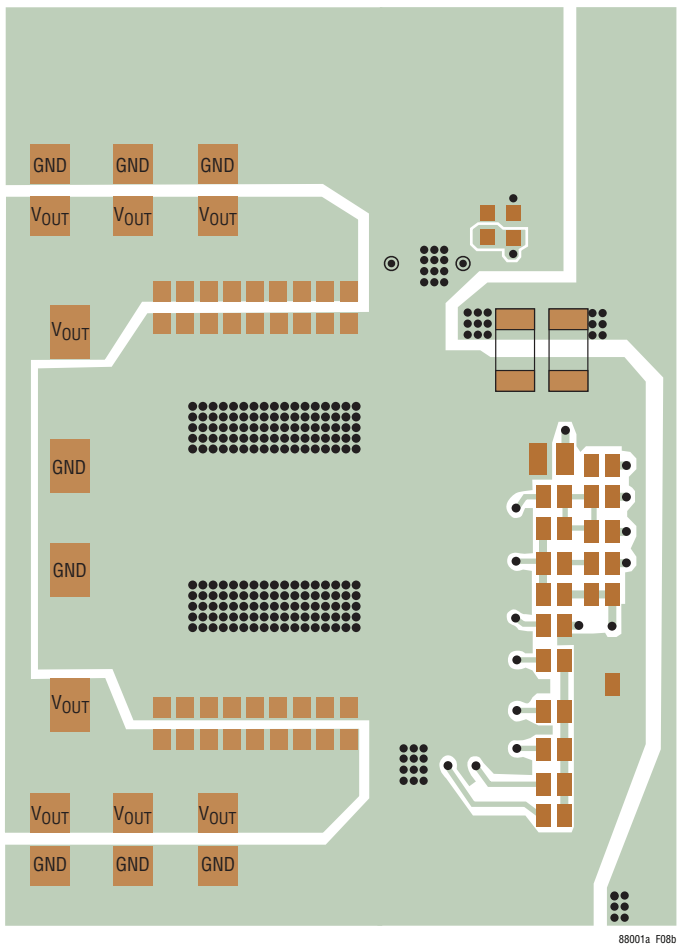


Figure 7. Thermal Derating $54V_{IN}$, $0.75V_{OUT}$



(a) Top Layers



(b) Bottom Layers

Figure 8. Recommended PCB Layout, Top View

TYPICAL APPLICATIONS

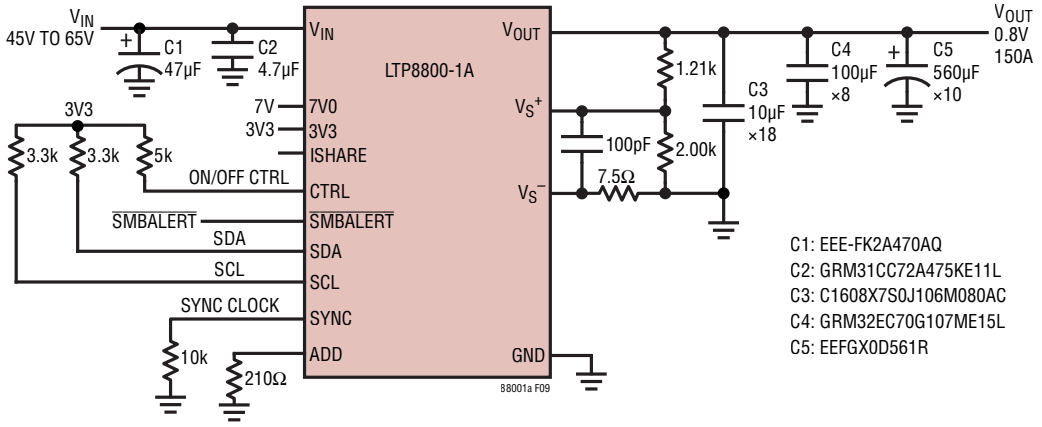


Figure 9. 0.8V 150A 1MHz Step-Down µModule with PMBus

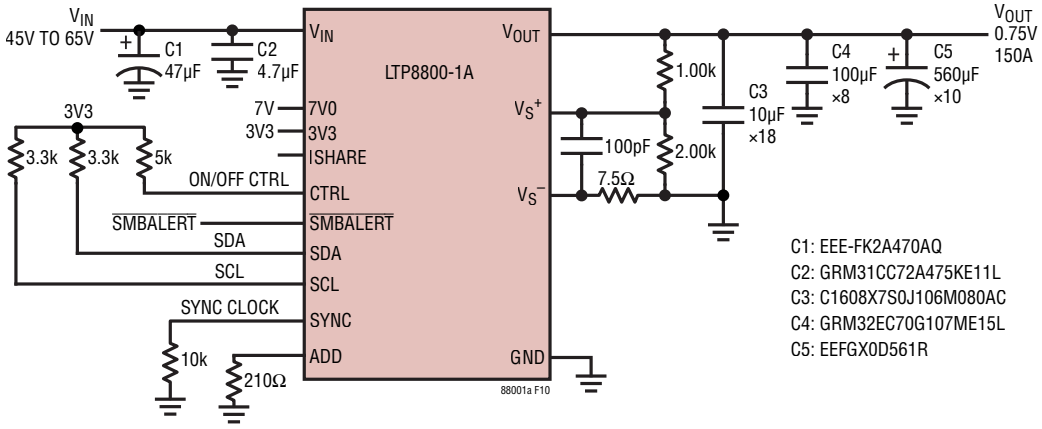


Figure 10. 0.75V 150A 1MHz Step-Down µModule with PMBus

TYPICAL APPLICATIONS

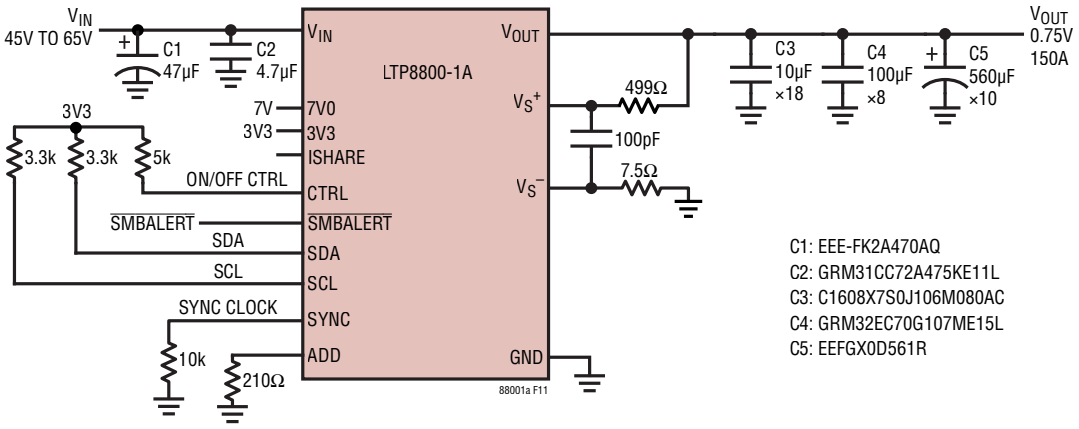


Figure 11. 0.75V 150A 1MHz Step-Down µModule with Unity Gain for Faster Transient Response

Utilizing unity gain provides better DC accuracy and transient response. See Compensation Section for determining PID settings for optimal loop response. LTP8800-1A requires the following registers to be adjusted for correct output voltage are listed in Table 3.

Table 3. Unity Gain Application PMBus Commands

REGISTER OFFSETS	ADI FACTORY SETTINGS	UNITY GAIN APPLICATION SETTINGS
VOUT_COMMAND (0x21h)	0x3000h	0x3000h
VOUT_SCALE_LOOP (0x29h)	0xB2A6h	0xBA00h
VOUT_SCALE_MONITOR (0x2Ah)	0xB2A6h	0xBA00h

TYPICAL APPLICATIONS

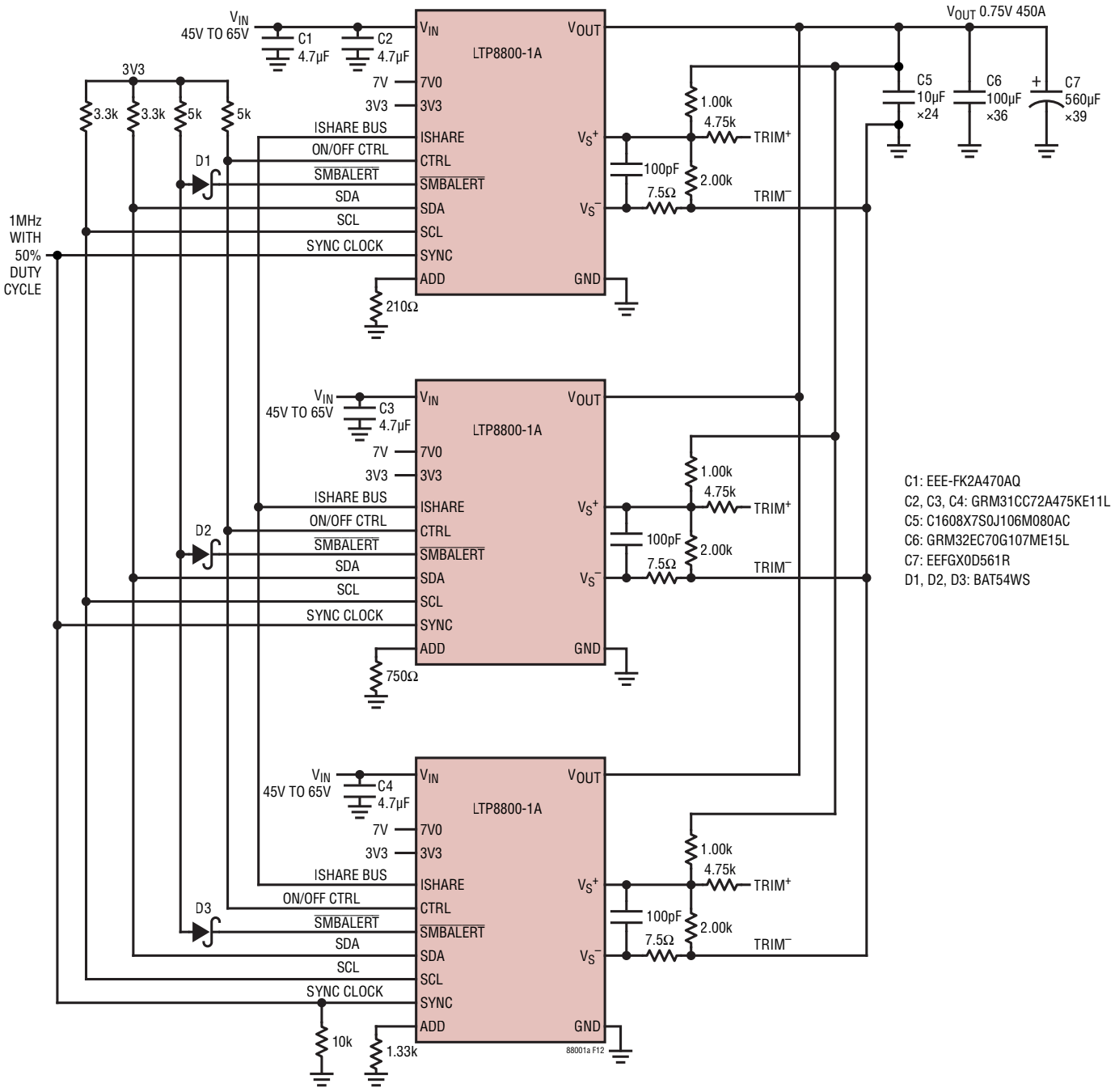
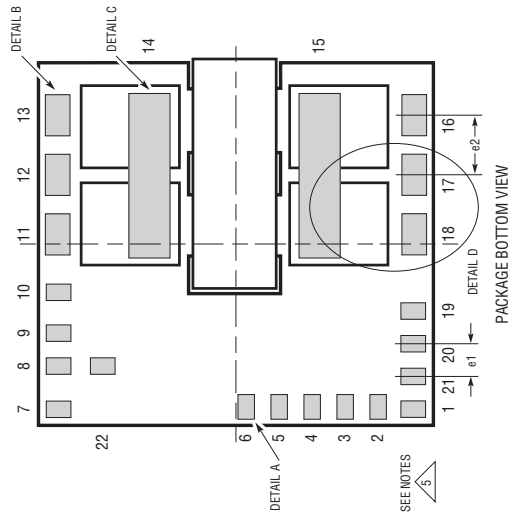
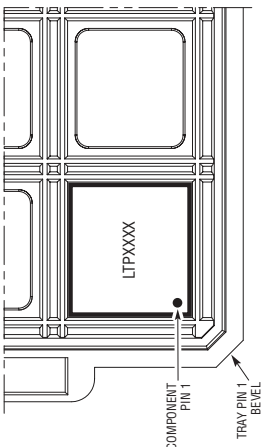


Figure 12. 3-Phase Operation Producing 0.75V at 450A with Power System Management Features

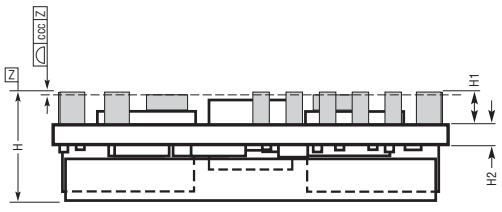
PACKAGE DESCRIPTION



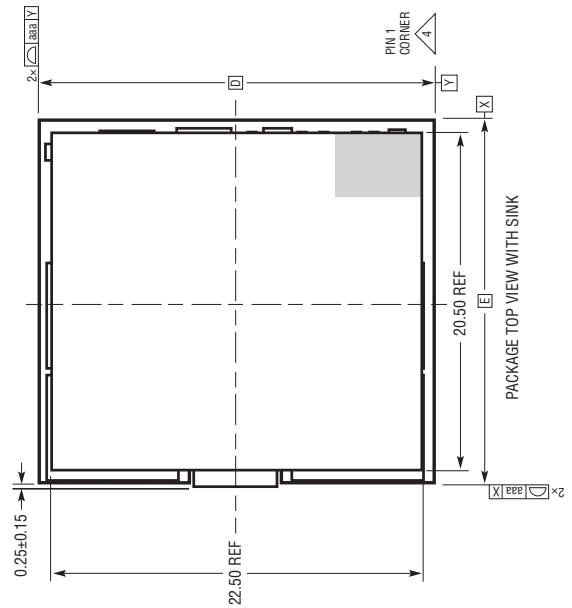
NOTES:
1. DIMENSIONING AND TOLERANCING PER ASME Y14.5M-1994
2. ALL DIMENSIONS ARE IN MILLIMETERS
3. PRIMARY DATUM -Z- IS SEATING PLANE
4. DETAILS OF PIN 1 IDENTIFIER ARE OPTIONAL, BUT MUST BE LOCATED WITHIN THE ZONE INDICATED. THE PIN 1 IDENTIFIER MAY BE EITHER A MOLD OR MARKED FEATURE
5. PACKAGE PIN LABELING MAY VARY AMONG PRODUCTS. REVIEW EACH PACKAGE LAYOUT CAREFULLY

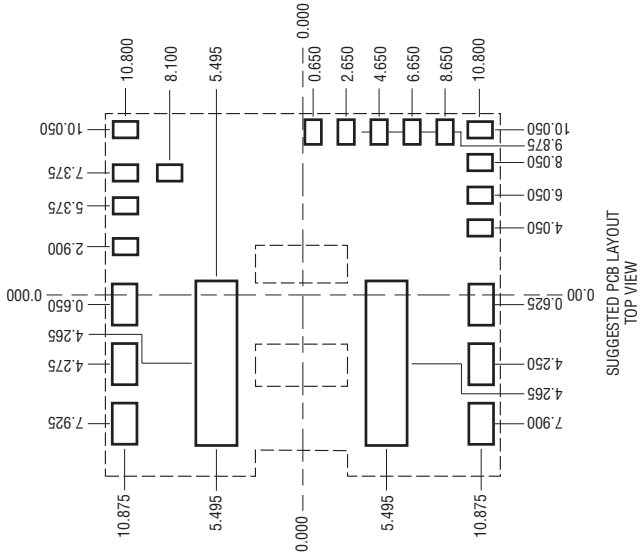


PCA Package
22-Lead (22mm × 24mm × 6.70mm)
(Reference LTC DWG #05-08-7006 Rev B)



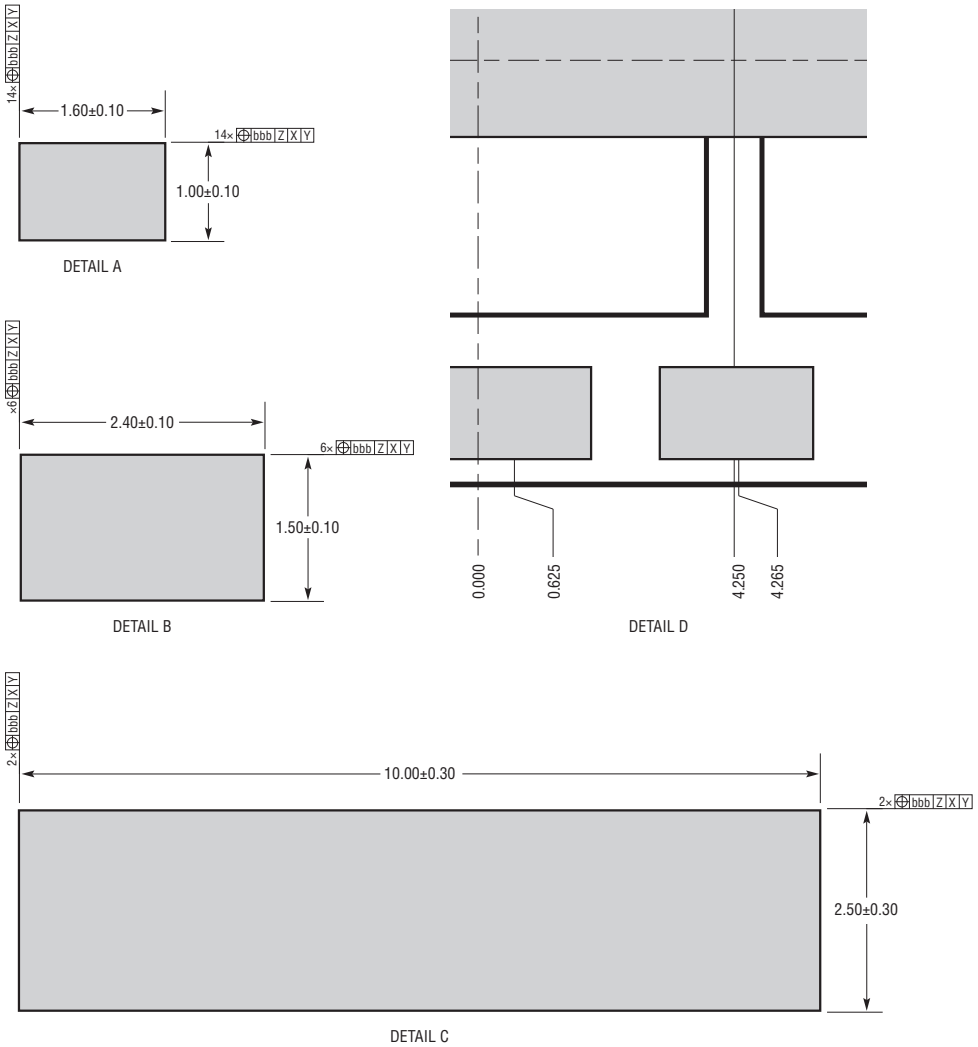
DIMENSIONS				
SYMBOL	MIN	NOM	MAX	NOTES
D		24.00		
E		22.00		
H	6.35	6.70	7.05	
H1	1.70	1.90	2.10	
H2	1.05	1.20	1.35	PCB THK
e1		2.00		
e2		3.65		
aaa			0.20	
bbb			0.40	
ccc			0.20	
ddd			0.35	
TOTAL NUMBER OF INTERCONNECTS: 22				





PACKAGE DESCRIPTION

PCA Package
22-Lead (22mm × 24mm × 6.70mm)
(Reference LTC DWG #05-08-7006 Rev B)

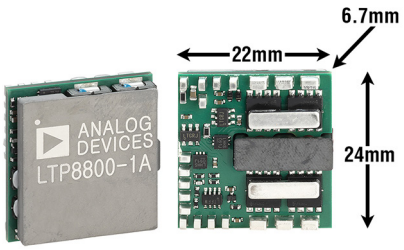


REVISION HISTORY

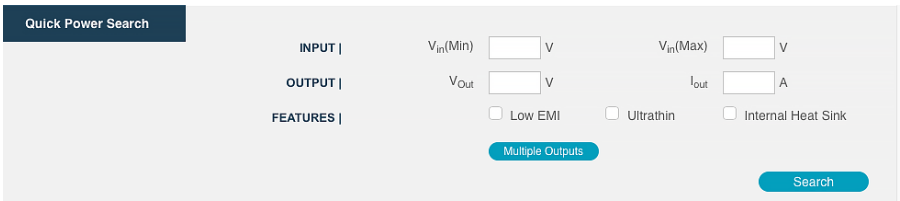
REV	DATE	DESCRIPTION	PAGE NUMBER
SpA	10/22	Changed Module to µModule.	All
		Removed Tape and Reel criteria.	2
		Corrected LFG and HFG values for Equation 1.	8
		Updated Figure 8 (Recommended PCB Layout drawing).	13
B	6/23	Release to open market	—

PACKAGE PHOTOS

Part marking is either ink mark or laser mark



DESIGN RESOURCES

SUBJECT	DESCRIPTION	
µModule Design and Manufacturing Resources	Design: • Selector Guides • Demo Boards and Gerber Files • Free Simulation Tools	Manufacturing: • Quick Start Guide • PCB Design, Assembly and Manufacturing Guidelines • Package and Board Level Reliability
µModule Regulator Products Search	1. Sort table of products by parameters and download the result as a spread sheet. 2. Search using the Quick Power Search parametric table. 	
Digital Power System Management	Analog Devices' family of digital power supply management ICs are highly integrated solutions that offer essential functions, including power supply monitoring, supervision, margining and sequencing, and feature EEPROM for storing user configurations and fault logging.	

RELATED PARTS

PART NUMBER	DESCRIPTION	COMMENTS
LTP8800-4A	54V_{IN}, 200A µModule Regulator with Digital Power System Management, Optimized 0.8V_{OUT}	45V ≤ V_{IN} ≤ 65V, 0.5V ≤ V_{OUT} ≤ 1.1V, PMBus with Control and Telemetry, ±0.5% of Maximum DC Output Error, 22mm × 24mm × 22mm Surface-Mount Package
LTP8802A-1A	54V_{IN}, 140A µModule Regulator with Digital Power System Management, Optimized 3.3V_{OUT}	45V ≤ V_{IN} ≤ 65V, 0.5V ≤ V_{OUT} ≤ 3.6V, PMBus with Control and Telemetry, ±0.5% of Maximum DC Output Error, 22mm × 24mm × 22mm Surface-Mount Package
LTP8803-1A	54V_{IN}, 140A µModule Regulator with Digital Power System Management, Optimized 1.2V_{OUT}	45V ≤ V_{IN} ≤ 65V, 0.5V ≤ V_{OUT} ≤ 1.5V, PMBus with Control and Telemetry, ±0.5% of Maximum DC Output Error, 22mm × 24mm × 22mm Surface-Mount Package
LTM®4664	54V_{IN}, Dual 25A or Single 50A µModule Regulator with Digital Power System Management	30V ≤ V_{IN} ≤ 58V, 0.5V ≤ V_{OUT} ≤ 1.5V, PMBus with Control and Telemetry, ±0.5% of Maximum DC Output Error, 16mm × 16mm × 7.72mm BGA Package
LTM4664A	54V_{IN}, Dual 30A or Single 60A µModule Regulator with Digital Power System Management	30V ≤ V_{IN} ≤ 58V, 0.5V ≤ V_{OUT} ≤ 1.2V. PMBus with Control and Telemetry, ±0.5% of Maximum DC Output Error. 16mm × 16mm × 7.72mm BGA Package.
LTM4700	Dual 50A or Single 100A µModule Regulator with Digital Power System Management	4.5V ≤ V_{IN} ≤ 16V, 0.5V ≤ V_{OUT} ≤ 1.8V, PMBus with Control and Telemetry, ±0.5% of Maximum DC Output Error, 15mm × 22mm × 7.87mm BGA Package
LTM4681	Quad 31.25A or Single 125A µModule Regulator with Digital Power System Management	4.5V ≤ V_{IN} ≤ 16V, 0.5V ≤ V_{OUT} ≤ 3.3V, PMBus with Control and Telemetry, ±0.5% of Maximum DC Output Error. 15mm × 22mm × 8.17mm BGA Package.
LTM4660	60V, 300W Non-Isolated µModule Bus Converter	30V ≤ V_{IN} ≤ 60V, 7.5V ≤ V_{OUT} ≤ 18V, Up to 300W, 16mm × 16mm × 10.34 BGA Package