

## FEATURES

- Fully Compliant with the Intel VRM 8.5 VID Specification
- Programs Regulator Output Voltage from 1.05V to 1.825V in 25mV Steps
- Programs an Entire Family of Linear Technology DC/DC Converters with 0.8V References
- $\pm 0.25\%$  Voltage Programming Accuracy
- Built-In 40k Pull-Up Resistors on Program Inputs
- Available in MSOP-10 Packaging

## APPLICATIONS

- Server/Desktop Computers
- Multiprocessor Workstations and Servers
- Multiphase Processor Power Supply

## DESCRIPTION

The LTC<sup>®</sup>1706-85 is a precision, digitally programmed resistive ladder which adjusts the output of any 0.8V-referenced regulator. Depending on the state of the five VID inputs, an output voltage between 1.05V and 1.825V is programmed in 25mV increments.

The LTC1706-85 is designed specifically to program an entire family of Linear Technology DC/DC converters in full compliance with the Intel Voltage Regulator Module (VRM) 8.5 specification.

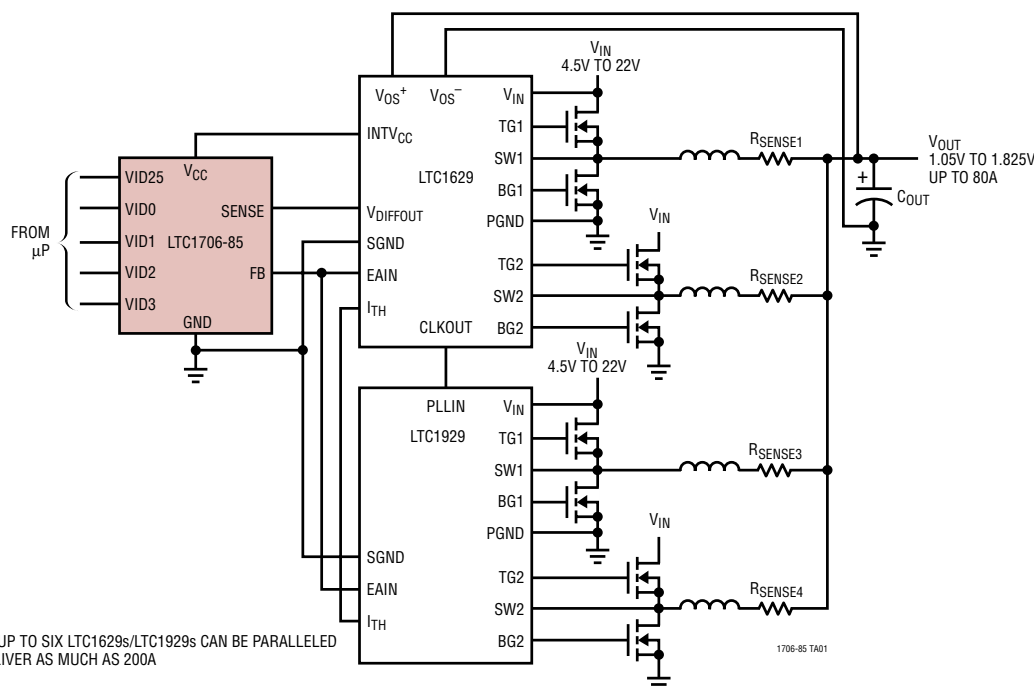
The LTC1706-85 programs the following Linear Technology DC/DC converter products: LTC1622, LTC1628, LTC1629, LTC1702, LTC1735, LTC1735-1, LTC1772, LTC1773, LTC1778, LTC1929, LTC3728 and LTC3729.

Consult factory for additional DC/DC converter products compatible with the LTC1706-85.

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## TYPICAL APPLICATION

**VID Controlled High Current 4-Phase DC/DC Converter (Simplified Block Diagram)**



## ABSOLUTE MAXIMUM RATINGS

(Notes 1, 2)

Input Supply Voltage ( $V_{CC}$ ) .....	-0.3V to 7V
VID Input Pins .....	-0.3V to 7V
SENSE Pin .....	-0.3V to 7V
FB Pin .....	-0.3V to 7V
Operating Temperature Range (Note 3) ..	-40°C to 85°C
Junction Temperature .....	110°C
Storage Temperature Range .....	-65°C to 150°C
Lead Temperature (Soldering, 10 sec) .....	300°C

## PACKAGE/ORDER INFORMATION

<p>TOP VIEW</p> <p>MS PACKAGE 10-LEAD PLASTIC MSOP</p> <p><math>T_{jMAX} = 110^{\circ}\text{C}</math>, <math>\theta_{JA} = 200^{\circ}\text{C/W}</math></p>	ORDER PART NUMBER
	LTC1706EMS-85
	MS PART MARKING
	LTYQ

Consult LTC Marketing 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  $T_A = 25^{\circ}\text{C}$ .  $2.7\text{V} \leq V_{CC} \leq 5.5\text{V}$ ,  $\text{VID}_{25} = \text{VID}_0 = \text{VID}_1 = \text{VID}_2 = \text{VID}_3 = \text{NC}$  unless otherwise noted. (Note 3)

SYMBOL	PARAMETER	CONDITIONS	MIN	TYP	MAX	UNITS	
$V_{CC}$	Operating Supply Voltage Range		2.7		5.5	V	
$I_{VCC}$	Supply Current	(Note 4)		1	10	$\mu\text{A}$	
$R_{FB1}$	Resistance Between SENSE and FB		● 6	10	14	$\text{k}\Omega$	
$V_{\text{OUT(ERROR)}}$	Output Voltage Accuracy	$1.050 \leq V_{\text{SENSE}} \leq 1.825\text{V}$	● -0.25		0.25	%	
$R_{\text{PULLUP}}$	Pull-Up Resistance on VID	$V_{\text{DIODE}} = 0.6\text{V}$ (Note 5)		28	40	56	$\text{k}\Omega$
$V_{\text{IH}}$	Minimum High Level Input Voltage (VID Inputs)	$V_{CC} = 3.3\text{V}$		2		V	
$V_{\text{IL}}$	Maximum Low Level Input Voltage (VID Inputs)	$V_{CC} = 3.3\text{V}$			0.8	V	
$I_{\text{IN}}$	Input Leakage Current (VID Inputs)	$V_{CC} < \text{VID} < 7\text{V}$ (Note 5)		0.01	$\pm 1$	$\mu\text{A}$	

**Note 1:** Absolute Maximum Ratings are those values beyond which the life of a device may be impaired.

**Note 2:** All voltages are with respect to GND pin.

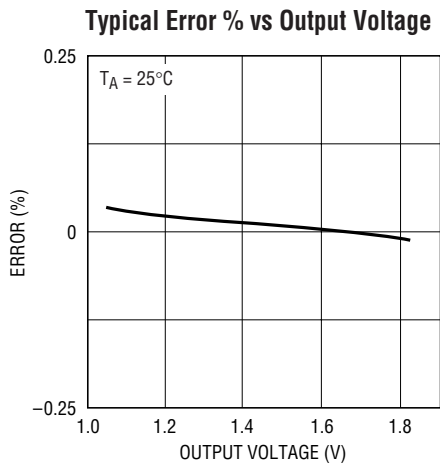
**Note 3:** The LTC1706-85 is guaranteed to meet performance specifications from 0°C to 70°C. Specifications over the -40°C to 85°C operating temperature range are assured by design, characterization and correlation with statistical process controls.

**Note 4:** Supply current is specified with all VID inputs floating. Due to the internal pull-ups on the VID pins, the supply current will increase

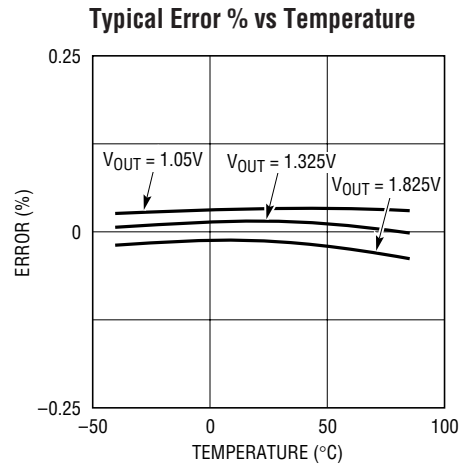
depending on the number of grounded VID lines. Each grounded VID line will draw approximately  $[(V_{CC} - 0.6)/40]\text{mA}$ . If the VID inputs are left unconnected, they will float to  $V_{CC}$  at a rate controlled by parasitic capacitance. Until the VID inputs reach their final states, slightly higher  $I_{VCC}$  current may be observed. (See the Operation section for more detail.)

**Note 5:** Each built-in pull-up resistor attached to the VID inputs also has a series diode connected to  $V_{CC}$  to allow input voltages higher than the  $V_{CC}$  supply without damage or clamping. (See Operation section for further details.)

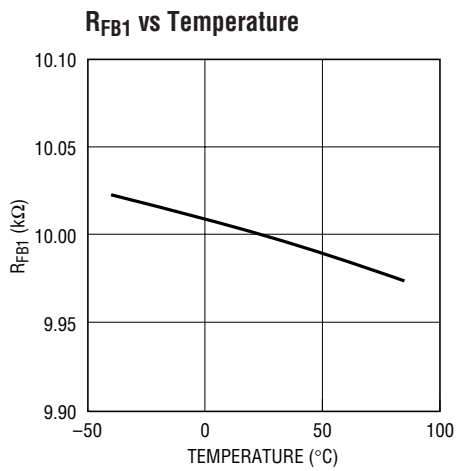
# TYPICAL PERFORMANCE CHARACTERISTICS



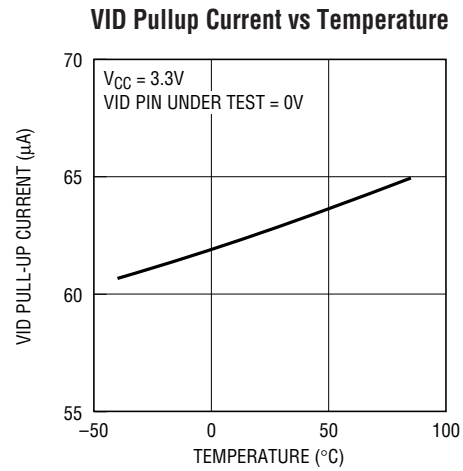
1706-85 G01



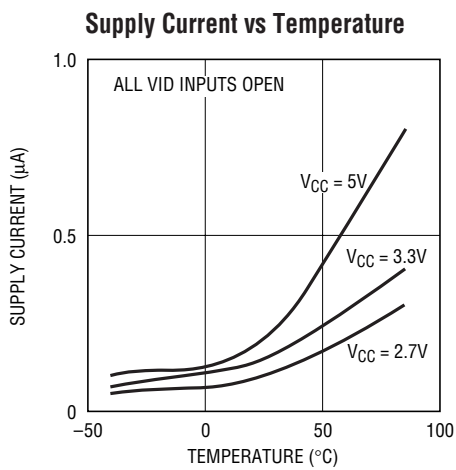
1706-85 G02



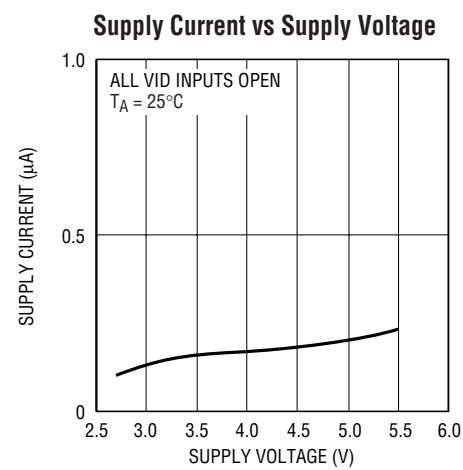
1706-85 G03



1706-85 G04



1706-85 G05



1706-85 G06

## PIN FUNCTIONS

**VID25 (Pin 1):** Programming Input. GND = LOW,  $V_{CC}$  or Float = HIGH. Refer to Table 1 for programming information. Connect to associated VID pin of  $\mu P$ .

**VID0 (Pin 2):** Programming Input. GND = LOW,  $V_{CC}$  or Float = HIGH. Refer to Table 1 for programming information. Connect to associated VID pin of  $\mu P$ .

**VID1 (Pin 3):** Programming Input. GND = LOW,  $V_{CC}$  or Float = HIGH. Refer to Table 1 for programming information. Connect to associated VID pin of  $\mu P$ .

**VID2 (Pin 4):** Programming Input. GND = LOW,  $V_{CC}$  or Float = HIGH. Refer to Table 1 for programming information. Connect to associated VID pin of  $\mu P$ .

**$V_{CC}$  (Pin 5):** Power Supply Voltage. May range from 2.7V to 5.5V.

**SENSE (Pin 6):** Regulator Output Voltage. Connect directly to regulator output sense node or  $V_{DIFFOUT}$  when used with the LTC1929 or LTC1629.

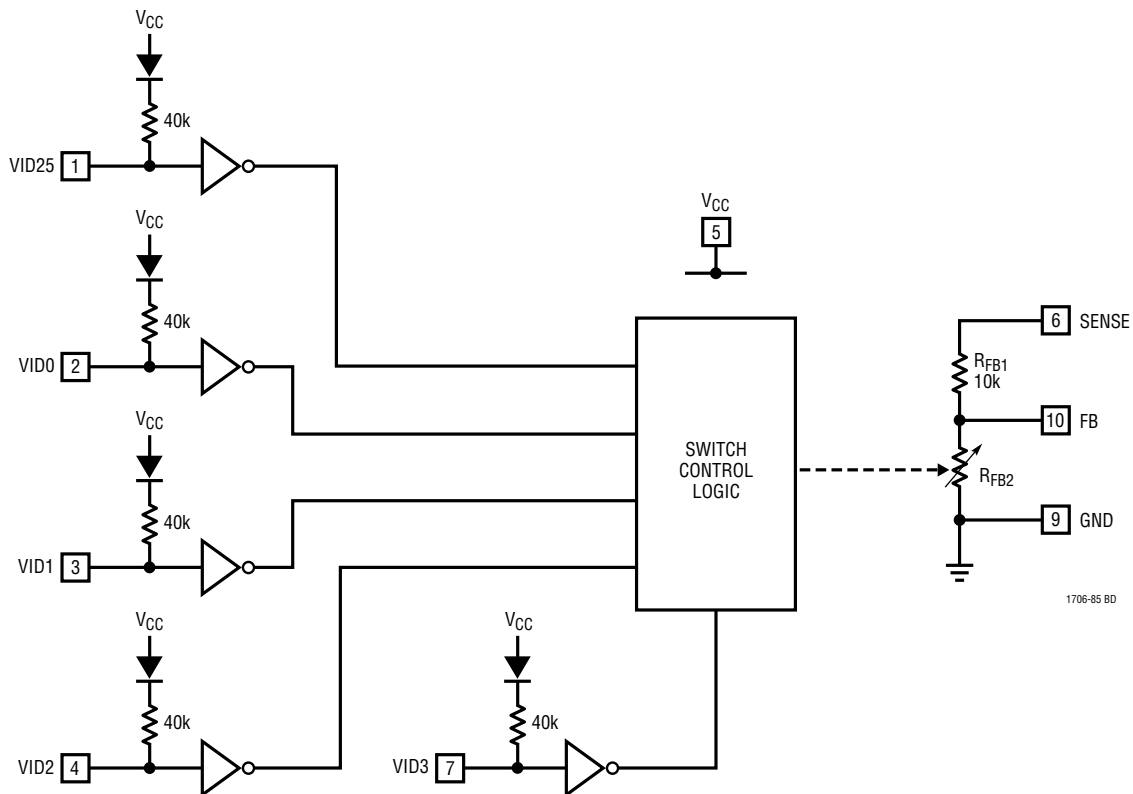
**VID3 (Pin 7):** Programming Input. GND = LOW,  $V_{CC}$  or Float = HIGH. Refer to Table 1 for programming information. Connect to associated VID pin of  $\mu P$ .

**NC (PIN 8):** No Connect.

**GND (Pin 9):** Ground. Connect to regulator signal ground.

**FB (Pin 10):** Feedback Input. Connect to the 0.8V feedback pin of a compatible regulator or the EAIN pin of the LTC1929 or LTC1629.

## BLOCK DIAGRAM



## OPERATION

The LTC1706-85 is a precision programmable resistive divider designed specifically for use with an entire family of Linear Technology Corporation DC/DC switching regulators with 0.8V internal reference and feedback voltages. The LTC1706-85 programs an output voltage ranging from 1.050V to 1.825V in 25mV steps, depending on the state of the VID input pins. The LTC1706-85 in conjunction with a Linear Technology DC/DC switching regulator can be used to create a high performance voltage regulator meeting all the requirements of the Intel VRM 8.5 specification.

### Voltage Sensing and Feedback Pins

The LTC1706-85 operates by closing the loop between the output node and the feedback node of the regulator with an appropriate resistive divider network. The “top” feedback resistor,  $R_{FB1}$ , connected between SENSE and FB, is a fixed value of typically 10k. The “bottom” feedback resistor,  $R_{FB2}$ , is set by the five VID inputs to generate the desired regulator output voltage. Feedback resistors  $R_{FB1}$  and  $R_{FB2}$  are matched and temperature stable in order to provide a highly accurate output voltage.

The FB pin is a sensitive node in the circuit. Care should be taken to minimize the layout distance between the LTC1706-85 FB node and the regulator feedback node. In addition, it is important to keep tight ground connections between the two chips.

### VID Inputs

The desired output voltage is obtained by applying the proper voltage or float condition to the five digital VID inputs. Table 1 shows the translation table with each input state and the corresponding regulator output voltage. This translation is derived from and adheres to the Intel VRM 8.5 specification.

Each VID input is pulled up by a 40k resistor in series with a diode connected to  $V_{CC}$ . To produce a digital low a VID

input should be grounded or driven to a low state. The VID inputs must be driven with a maximum  $V_{IL}$  of 0.8V ( $V_{CC} = 3.3V$ ).

When a VID input is grounded or pulled low with a logic gate, the power supply current will increase because of the resistor from  $V_{CC}$  through the series diode to the input. This increase in current is calculated from:

$$I_Q = N \cdot (V_{CC} - V_{DIODE})/R_{PULLUP}$$

where N is the number of grounded VID inputs. With typical values of  $V_{CC} = 3.3V$ ,  $V_{DIODE} = 0.6V$  and  $R_{PULLUP} = 40k$ , each grounded  $V_{IN}$  input will sink approximately 68 $\mu$ A.

To apply a digital high state the input can be either floated, connected to  $V_{CC}$  or driven by a logic gate. The VID inputs should be driven with a minimum  $V_{IH}$  of 2V ( $V_{CC} = 3.3V$ ). Because of the diode between  $V_{CC}$  and the pull-up resistor, the maximum  $V_{IH}$  is not limited to  $V_{CC}$ . The VID inputs can be driven higher than  $V_{CC}$  without being clamped or damaged. This allows the LTC1706-85 to be fully logic compatible and operational over a wide input voltage range, up to the 7V absolute maximum rating.

When used with the LTC1629 and LTC1929, the LTC1706-85's FB, SENSE,  $V_{CC}$  and GND pins should be connected respectively to the EAIN,  $V_{DIFFOUT}$ , INT $V_{CC}$  and SGND pins of the LTC1629 and LTC1929. The result of this application is a precisely controlled, multiphase, variable output voltage supply applicable to any low output voltage system such as a personal computer, workstation or network server.

In addition to the LTC1629 and LTC1929, the LTC1706-85 also programs a whole family of LTC DC/DC converters that have an onboard 0.8V reference. The LTC1628, LTC1735 and LTC1622 are just a few of the high efficiency step-down switching regulators that will work equally well with the LTC1706-85. Contact LTC Marketing for a more complete listing of compatible DC/DC regulators.

## OPERATION

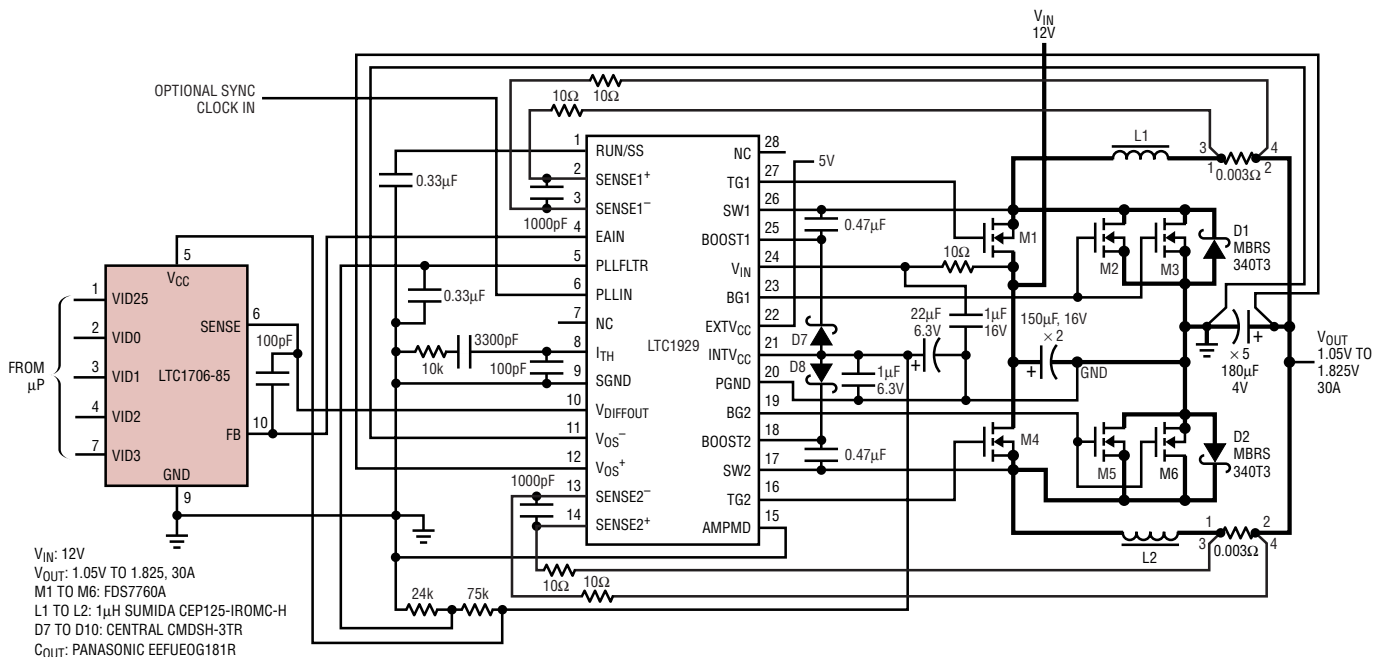
**Table 1. VID Inputs and Corresponding Output Voltage**

CODE	VID3	VID2	VID1	VID0	VID25	VOLTAGE
00000	GND	GND	GND	GND	GND	1.250
00001	GND	GND	GND	GND	Float	1.275
00010	GND	GND	GND	Float	GND	1.200
00011	GND	GND	GND	Float	Float	1.225
00100	GND	GND	Float	GND	GND	1.150
00101	GND	GND	Float	GND	Float	1.175
00110	GND	GND	Float	Float	GND	1.100
00111	GND	GND	Float	Float	Float	1.125
01000	GND	Float	GND	GND	GND	1.050
01001	GND	Float	GND	GND	Float	1.075
01010	GND	Float	GND	Float	GND	1.800
01011	GND	Float	GND	Float	Float	1.825
01100	GND	Float	Float	GND	GND	1.750
01101	GND	Float	Float	GND	Float	1.775
01110	GND	Float	Float	Float	GND	1.700
01111	GND	Float	Float	Float	Float	1.725

CODE	VID3	VID2	VID1	VID0	VID25	VOLTAGE
10000	Float	GND	GND	GND	GND	1.650
10001	Float	GND	GND	GND	Float	1.675
10010	Float	GND	GND	Float	GND	1.600
10011	Float	GND	GND	Float	Float	1.625
10100	Float	GND	Float	GND	GND	1.550
10101	Float	GND	Float	GND	Float	1.575
10110	Float	GND	Float	Float	GND	1.500
10111	Float	GND	Float	Float	Float	1.525
11000	Float	Float	GND	GND	GND	1.450
11001	Float	Float	GND	GND	Float	1.475
11010	Float	Float	GND	Float	GND	1.400
11011	Float	Float	GND	Float	Float	1.425
11100	Float	Float	Float	GND	GND	1.350
11101	Float	Float	Float	GND	Float	1.375
11110	Float	Float	Float	Float	GND	1.300
11111	Float	Float	Float	Float	Float	1.325

## TYPICAL APPLICATIONS

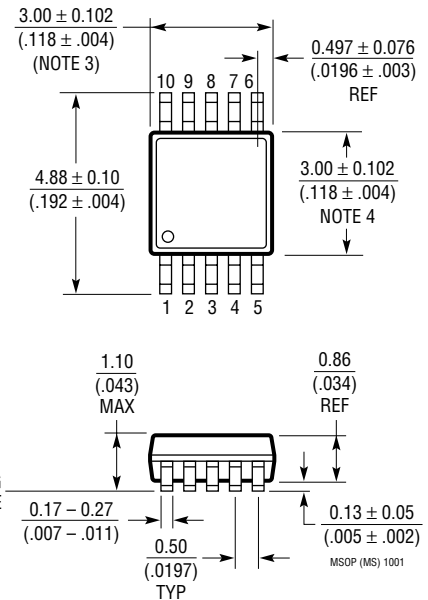
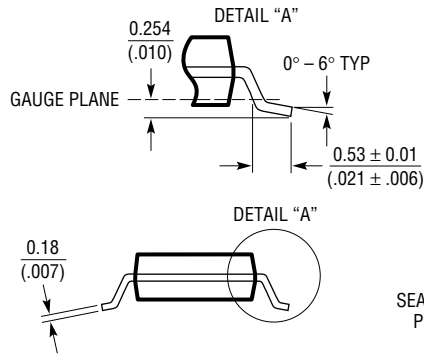
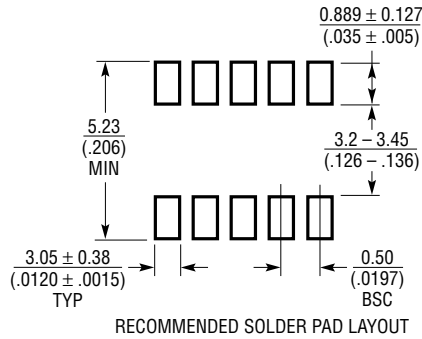
**30A, 2-Phase VID Controlled Power Supply**





## PACKAGE DESCRIPTION

**MS Package**  
**10-Lead Plastic MSOP**  
 (Reference LTC DWG # 05-08-1661)



- NOTE:
1. DIMENSIONS IN MILLIMETER/(INCH)
  2. DRAWING NOT TO SCALE
  3. DIMENSION DOES NOT INCLUDE MOLD FLASH, PROTRUSIONS OR GATE BURRS. MOLD FLASH, PROTRUSIONS OR GATE BURRS SHALL NOT EXCEED 0.152mm (.006") PER SIDE
  4. DIMENSION DOES NOT INCLUDE INTERLEAD FLASH OR PROTRUSIONS. INTERLEAD FLASH OR PROTRUSIONS SHALL NOT EXCEED 0.152mm (.006") PER SIDE
  5. LEAD COPLANARITY (BOTTOM OF LEADS AFTER FORMING) SHALL BE 0.102mm (.004") MAX

## RELATED PARTS

PART NUMBER	DESCRIPTION	COMMENTS
LTC1622	Synchronizable Low Voltage Step-Down Controller	8-Pin MSOP, $2V \leq V_{IN} \leq 10V$ , 550kHz, Burst Mode <sup>®</sup> Operation
LTC1628/LTC1628-PG	Dual High Efficiency, 2-Phase Sync Step-Down Controller	Constant Freq, Standby, 5V and 3.3V LDOs, $3.5V \leq V_{IN} \leq 36V$
LTC1629/LTC1629-PG	PolyPhase <sup>®</sup> High Efficiency Step-Down DC/DC Controller	Expandable Up to 12 Phases, Up to 200A, Remote Sense Diff Amp
LTC1702/LTC1703	Dual High Efficiency, 2-Phase Sync Step-Down Controller	550kHz, 25MHz GBW, No $R_{SENSE}^{TM}$ , $2.7V \leq V_{IN} \leq 7V$
LTC1706-81/LTC1706-82	VID Voltage Programmer with Desktop Code	VRM 8.2-VRM 8.4, $V_{OUT}$ Range: 1.3V to 3.5V
LTC1709/LTC1709-8	2-Phase Sync Step-Down Controller with 5-Bit Desktop VID	$4V \leq V_{IN} \leq 36V$ , PLL, 36-Pin SSOP, Current Mode Operation
LT1709-85	2-Phase, 5-Bit VID, Current Mode High Efficiency Synchronous Step-Down Switching Regulator	$4V \leq V_{IN} \leq 36V$ , 36-Pin SSOP VRM 8.5 Compatible
LTC1735	High Efficiency Sync Step-Down Controller	Burst Mode Operation, 16-Pin Narrow SSOP, Fault Protection, $3.5V \leq V_{IN} \leq 36V$
LTC1736	High Efficiency Sync Buck Controller with 5-Bit Mobile VID	GN-24, Power Good, Output Fault Protection, $3.5V \leq V_{IN} \leq 36V$
LTC1772	SOT-23 Low Voltage Step-Down Controller	6-Pin SOT-23, $2.5V \leq V_{IN} \leq 10V$ , 550kHz, Burst Mode Operation
LTC1773	Synchronous Step-Down DC/DC Controller	Up to 95% Efficiency, 550kHz Operation, $2.65V \leq V_{IN} \leq 8.5V$ , $0.8 \leq V_{OUT} \leq V_{IN}$
LTC1778	Wide Operating Range Step-Down Controller	No $R_{SENSE}$ , $V_{IN}$ up to 36V, Current Mode Power Good
LTC1929/LTC1929-PG	2-Phase Sync Step-Down Controller	Current Mode Operation, $I_{OUT}$ Up to 40A, $3.5V \leq V_{IN} \leq 36V$
LTC3728	550kHz, 2-Phase Dual Output Synchronous Step-Down Controller	Synchronizable, Current Mode, $3.5V \leq V_{IN} \leq 36V$ , $I_{OUT}$ up to 25A
LTC3729	550kHz, PolyPhase, High Efficiency Synchronous Step-Down Switching Regulator	Current Mode, $4V \leq V_{IN} \leq 36V$ , 28-Lead SSOP package

Burst Mode and PolyPhase are registered trademarks of Linear Technology Corporation.  
 No  $R_{SENSE}$  is a trademark of Linear Technology Corporation.