



**THE DATASHEET OF  
LTC1706EMS-81#PBF**



# 5-Bit Desktop VID Voltage Programmer

## FEATURES

- Programs Regulator Output Voltage Range from 1.3V to 2.05V in 50mV Steps and from 2.1V to 3.5V in 100mV Steps (VRM 8.4)
- Programs a Wide Range of Linear Technology DC/DC Converters with a 0.8V Reference
- Fully Compliant with the Intel Pentium® Processor Desktop VID Specification
- $\pm 0.25\%$  Accurate Output Voltage
- Built-In 40k Pull-Up Resistors on VID Inputs
- Available in MSOP-10 Package

## APPLICATIONS

- Intel Pentium II and III Processor Power Supply
- AMD Athlon™ Processor Power Supply
- Workstations and Servers
- Large Memory Array Supply

## DESCRIPTION

The LTC®1706-81 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 1.3V and 3.5V is programmed in 50mV and 100mV increments.

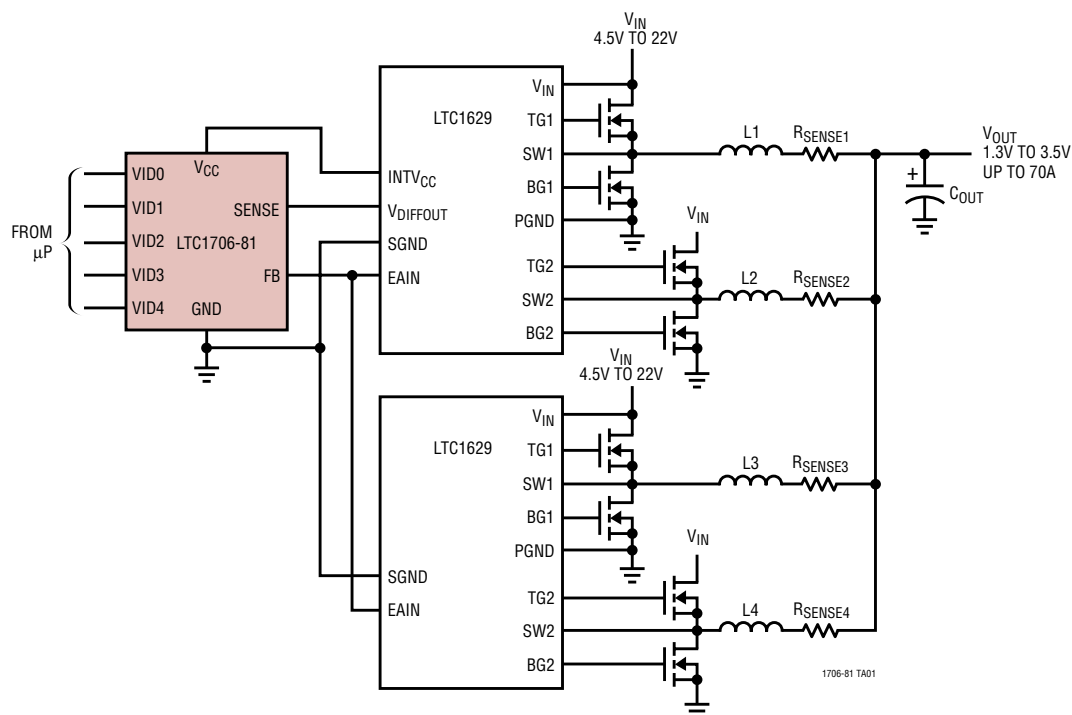
The LTC1706-81 is designed specifically to program an entire family of Linear Technology DC/DC converters in full compliance with the Intel Desktop (VRM 8.4) VID specification.

The LTC1706-81 programs the following Linear Technology DC/DC converter products: LTC1622, LTC1628, LTC1629, LTC1702, LTC1735, LTC1735-1, LTC1772 and LTC1929. (Consult factory for future compatible DC/DC converter products.)

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## TYPICAL APPLICATION

5-Bit VID-Controlled High Current 4-Phase Application (Simplified Block Diagram)



1706-81 TA01

## ABSOLUTE MAXIMUM RATINGS

(Note 1)

(Voltages Referred to GND Pin)

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 2)	–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

	ORDER PART NUMBER
	LTC1706EMS-81
	MS10 PART MARKING
	LTLR

Consult factory for Industrial and Military grade parts.

## ELECTRICAL CHARACTERISTICS

The ● denotes specifications which apply over the full operating temperature range, otherwise specifications are  $T_A = 25^\circ\text{C}$ .  $2.7\text{V} \leq V_{CC} \leq 5.5\text{V}$ ,  $\text{VID0} = \text{VID1} = \text{VID2} = \text{VID3} = \text{VID4} = \text{NC}$  unless otherwise specified.

SYMBOL	PARAMETER	CONDITIONS	MIN	TYP	MAX	UNITS
$V_{CC}$	Operating Supply Voltage Range		2.7		5.5	V
$I_{VCC}$	Supply Current	(Note 3)		0.1	5	$\mu\text{A}$
$R_{\text{FB-SENSE}}$	Resistance Between SENSE and FB		● 12	20	28	$\text{k}\Omega$
$V_{\text{OUT}}$ Error %	Output Voltage Accuracy	Programmed from 1.3V to 2.05V ( $\text{VID4} = 0$ ) Programmed from 2.1V to 3.5V ( $\text{VID4} = 1$ )	● –0.25		+0.25	%
$R_{\text{PULLUP}}$	VID Input Pull-Up Resistance	$V_{\text{DIODE}} = 0.6\text{V}$ (Note 4)		40		$\text{k}\Omega$
$\text{VID}_{\text{TH}}$	VID Input Voltage Threshold	$V_{\text{IL}}$ ( $2.7\text{V} \leq V_{CC} \leq 5.5\text{V}$ ) $V_{\text{IH}}$ ( $2.7\text{V} \leq V_{CC} \leq 5.5\text{V}$ )	1.6		0.4	V
$I_{\text{VID-LEAK}}$	VID Input Leakage Current	$V_{CC} < \text{VID} < 7\text{V}$ (Note 4)		0.01	$\pm 1$	$\mu\text{A}$
$V_{\text{PULLUP}}$	VID Pull-Up Voltage	$V_{CC} = 3.3\text{V}$ $V_{CC} = 5\text{V}$		2.8		V
				4.5		V

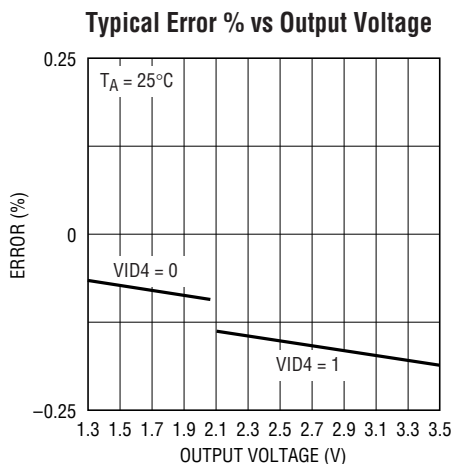
**Note 1:** Absolute Maximum Ratings are those values beyond which the life of a device may be impaired.

**Note 2:** The LTC1706-81 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.

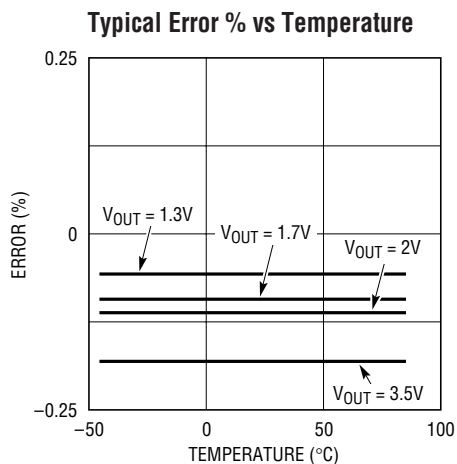
**Note 3:** With all five VID inputs floating, the  $V_{CC}$  supply current is simply the device leakage current. However, the  $V_{CC}$  supply current will rise and be approximately equal to the number of grounded VID input pins times  $(V_{CC} - 0.6\text{V})/40\text{k}$ . (See the VID Input Characteristics section for more details.)

**Note 4:** 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.)

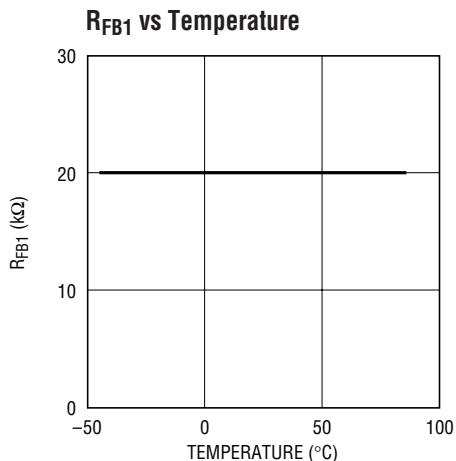
# TYPICAL PERFORMANCE CHARACTERISTICS



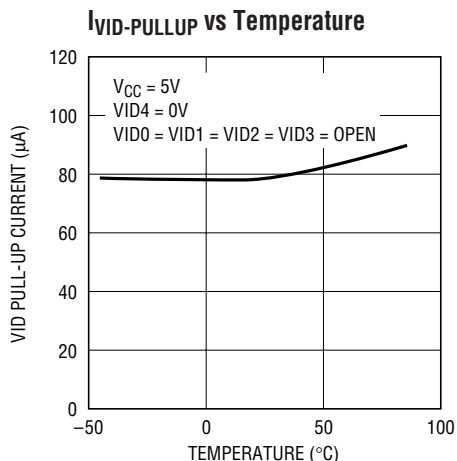
1706-81 G01



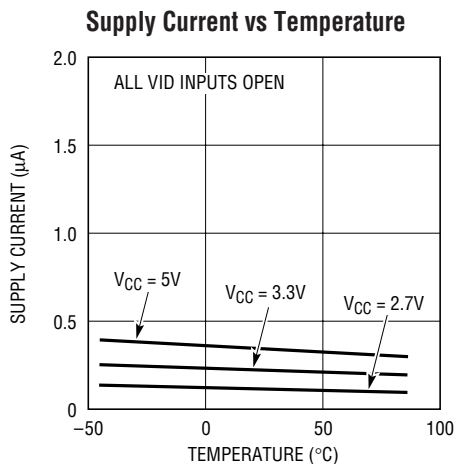
1706-81 G02



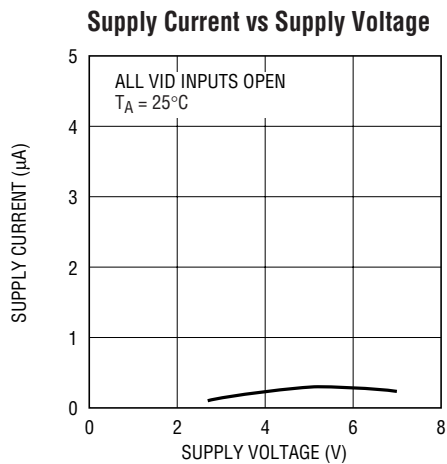
1706-81 G03



1706-81 G04



1706-81 G05



1706-81 G06

## PIN FUNCTIONS

**VID0 (Pin 1):** LSB Programming Input. Low = GND, High =  $V_{CC}$  or Float. Grounding VID0 adds 50mV (VID4 = LOW) or 100mV (VID4 = HIGH) to the output sense voltage.

**VID1 (Pin 2):** 3rd MSB Programming Input. Low = GND, High =  $V_{CC}$  or Float. Grounding VID1 adds 100mV (VID4 = LOW) or 200mV (VID4 = HIGH) to the output sense voltage.

**VID2 (Pin 3):** 2nd MSB Programming Input. Low = GND, High =  $V_{CC}$  or Float. Grounding VID2 adds 200mV (VID4 = LOW) or 400mV (VID4 = HIGH) to the output sense voltage.

**VID3 (Pin 4):** MSB Programming Input. Low = GND, High =  $V_{CC}$  or Float. Grounding VID3 adds 400mV (VID4 = LOW) or 800mV (VID4 = HIGH) to the output sense voltage.

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

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

**VID4 (Pin 7):** High-Low Output Range Programming Input. VID4 = Low puts the output voltage in the lower range of 1.3V to 2.05V in 50mV steps. VID4 = HIGH puts the output voltage in the upper range of 2.1V to 3.5V in 100mV steps.

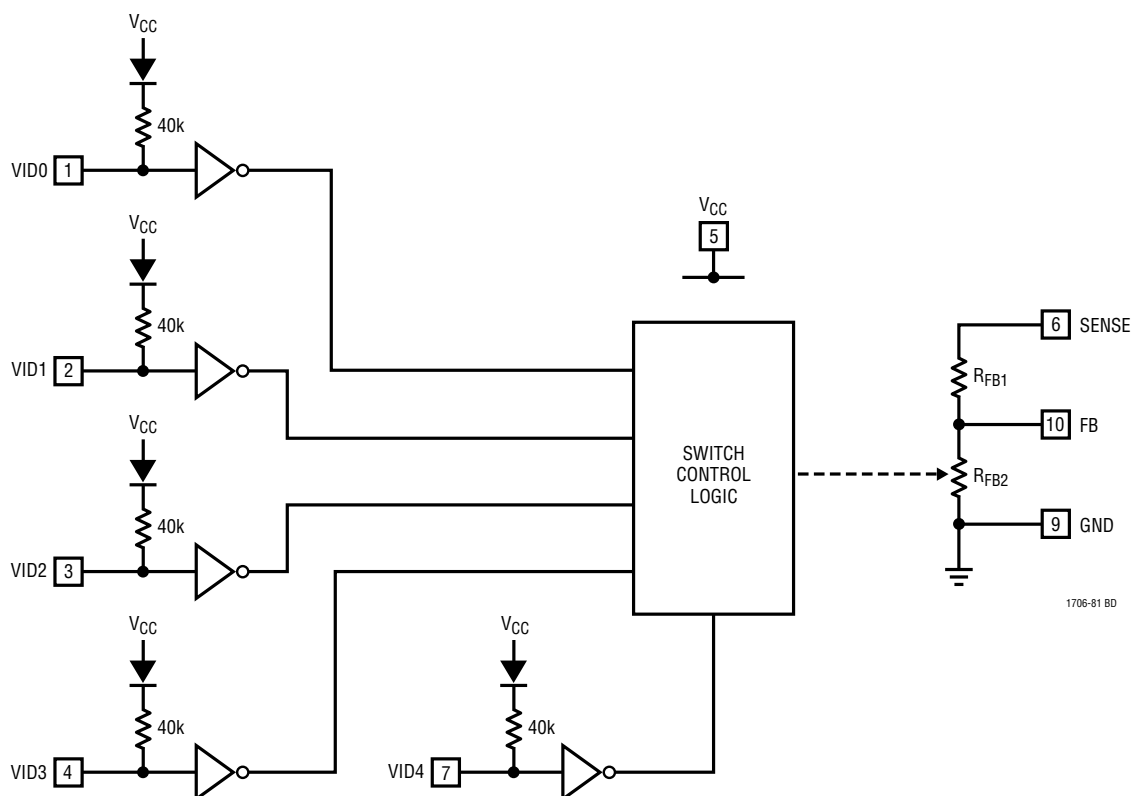
**NC (Pin 8):** No Connect.

**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 LTC1629 and LTC1929.

PIN	NAME	DESCRIPTION	NOMINAL (V)			ABSOLUTE MAX (V)	
			MIN	TYP	MAX	MIN	MAX
1	VID0	LSB Programmable Input	0		$V_{CC}$	-0.3	7
2	VID1	3rd MSB Programmable Input	0		$V_{CC}$	-0.3	7
3	VID2	2nd MSB Programmable Input	0		$V_{CC}$	-0.3	7
4	VID3	1st MSB Programmable Input	0		$V_{CC}$	-0.3	7
5	$V_{CC}$	Power Supply	2.7		5.5	-0.3	7
6	SENSE	Regulator Output Voltage	1.3		3.5	-0.3	7
7	VID4	Output Range Programmable Input	0		$V_{CC}$	-0.3	7
8	NC						
9	GND	Ground		0		-0.3	7
10	FB	0.8V Feedback Input	0	0.8	1.5	-0.3	7

## BLOCK DIAGRAM



## OPERATION

The LTC1706-81 is a precision 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 voltage. The LTC1706-81 produces an output voltage ranging from 1.3V to 2.05V in 50mV steps and from 2.1V to 3.5V in 100mV steps by closing the loop between the output voltage sense and the feedback input of the regulator with the appropriate resistive divider network.

The “top” feedback resistor,  $R_{FB1}$ , connected between SENSE and FB, is typically 20k and is not modified by the state of the VID program inputs.

The “bottom” feedback resistor,  $R_{FB2}$ , however, is modified by the five VID inputs and is precisely ratioed to  $R_{FB1}$ .

### VID Programming

A list of programmed inputs and their corresponding output voltages is shown in Table 1. Programming is accomplished by applying the proper voltage (or float condition) on the five digital VID inputs. VID4 is the range bit that puts the output voltage in either the 1.3V to 2.05V range or the 2.1V to 3.5V range. In either range, VID3 is the most significant bit (MSB) and VID0 is the least significant bit (LSB).

In the lower range (VID4 = 0), when the four VID inputs are low or grounded, the regulator output voltage is set to 2.05V. Each increasing binary count is equivalent to a decrease of 50mV in the output voltage. Therefore, to obtain a 1.3V output, the four VID inputs should be floating, or high.

## OPERATION

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

CODE	VID4	VID3	VID2	VID1	VID0	OUTPUT
10000	Float	GND	GND	GND	GND	3.5V
10001	Float	GND	GND	GND	Float	3.4V
10010	Float	GND	GND	Float	GND	3.3V
10011	Float	GND	GND	Float	Float	3.2V
10100	Float	GND	Float	GND	GND	3.1V
10101	Float	GND	Float	GND	Float	3.0V
10110	Float	GND	Float	Float	GND	2.9V
10111	Float	GND	Float	Float	Float	2.8V
11000	Float	Float	GND	GND	GND	2.7V
11001	Float	Float	GND	GND	Float	2.6V
11010	Float	Float	GND	Float	GND	2.5V
11011	Float	Float	GND	Float	Float	2.4V
11100	Float	Float	Float	GND	GND	2.3V
11101	Float	Float	Float	GND	Float	2.2V
11110	Float	Float	Float	Float	GND	2.1V
11111	Float	Float	Float	Float	Float	*
00000	GND	GND	GND	GND	GND	2.05V
00001	GND	GND	GND	GND	Float	2.00V
00010	GND	GND	GND	Float	GND	1.95V
00011	GND	GND	GND	Float	Float	1.90V
00100	GND	GND	Float	GND	GND	1.85V
00101	GND	GND	Float	GND	Float	1.80V
00110	GND	GND	Float	Float	GND	1.75V
00111	GND	GND	Float	Float	Float	1.70V
01000	GND	Float	GND	GND	GND	1.65V
01001	GND	Float	GND	GND	Float	1.60V
01010	GND	Float	GND	Float	GND	1.55V
01011	GND	Float	GND	Float	Float	1.50V
01100	GND	Float	Float	GND	GND	1.45V
01101	GND	Float	Float	GND	Float	1.40V
01110	GND	Float	Float	Float	GND	1.35V
01111	GND	Float	Float	Float	Float	1.30V

\* Represents codes without a defined output voltage as specified in Intel specifications. The LTC1706-81 interprets these codes as a valid input and produces an output voltage as follows: (11111) = 2V

To program output voltages higher than 2.05V, the range bit should be set high (VID4 = High). In this range, when the four VID inputs are low, the output is 3.5V. Each increasing binary count is equivalent to a decrease of 100mV in the output voltage.

When all five VID inputs are high or floating, such as when no CPU is present in a system, a regulated 2V output is generated at  $V_{SENSE}$ .

Each VID input pin is pulled up by a 40k resistor in series with a diode connected to  $V_{CC}$ . Therefore, it should be grounded (or driven low) to produce a digital low input. It can either be floated or connected to  $V_{CC}$  to get a digital high input. The series diode is included to prevent the input from being damaged or clamped when it is driven higher than  $V_{CC}$ .

### Voltage Sensing and Feedback Pins

The FB pin is a high impedance node that requires minimum layout distance to reduce extra loading and unwanted stray pickup.

When used with the LTC1629 or LTC1929, the LTC1706-81's FB, SENSE,  $V_{CC}$  and GND pins should be connected, respectively, with 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 to any low voltage, high current system such as a powerful personal computer, workstation or network server. True remote sense capability is retained in this case.

### VID Input Characteristics

The VID inputs should be driven with a maximum  $V_{IL}$  of 0.4V and a minimum  $V_{IH}$  of 1.6V. However, the VID input range is not limited to values less than  $V_{CC}$ . Because of the internal diode between  $V_{CC}$  and the pull-up resistor, the inputs can go higher than  $V_{CC}$  without being clamped to  $V_{CC}$  or damaging the input.

This allows the LTC1706-81 to be fully logic compatible and operational over a higher input voltage range (less than the 7V absolute maximum rating).

## APPLICATIONS INFORMATION

When a VID input is grounded, there will be a higher quiescent current flow from  $V_{CC}$  because of a resistor from  $V_{CC}$  through a series diode to each one of the inputs. This increase in quiescent current is calculated from:

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

$N$  is the number of grounded VID inputs.  $V_{DIODE}$  is typically 0.6V while  $R_{PULLUP}$  has a typical pull-up resistance of 40k $\Omega$ .

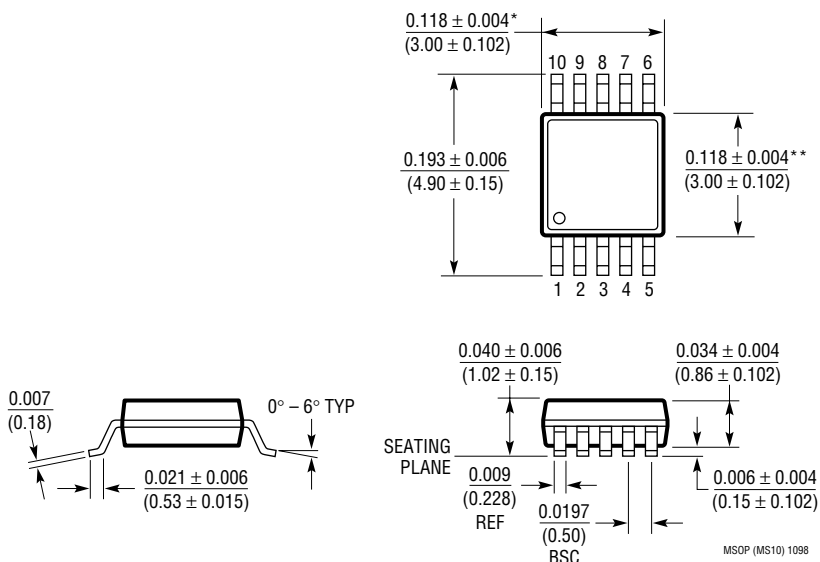
In other words, each VID input has a typical pull-up current of 68 $\mu$ A for a 3.3V system.

Besides the LTC1629, the LTC1706-81 also programs a whole family of LTC DC/DC converters that have an onboard 0.8V reference. The LTC1628, LTC1735, LTC1622, LTC1772 and LTC1929 are just a few of the high efficiency step-down switching regulators that will work equally well with the LTC1706-81.

## PACKAGE DESCRIPTION

Dimensions in inches (millimeters) unless otherwise noted.

**MS10 Package**  
**10-Lead Plastic MSOP**  
(LTC DWG # 05-08-1661)

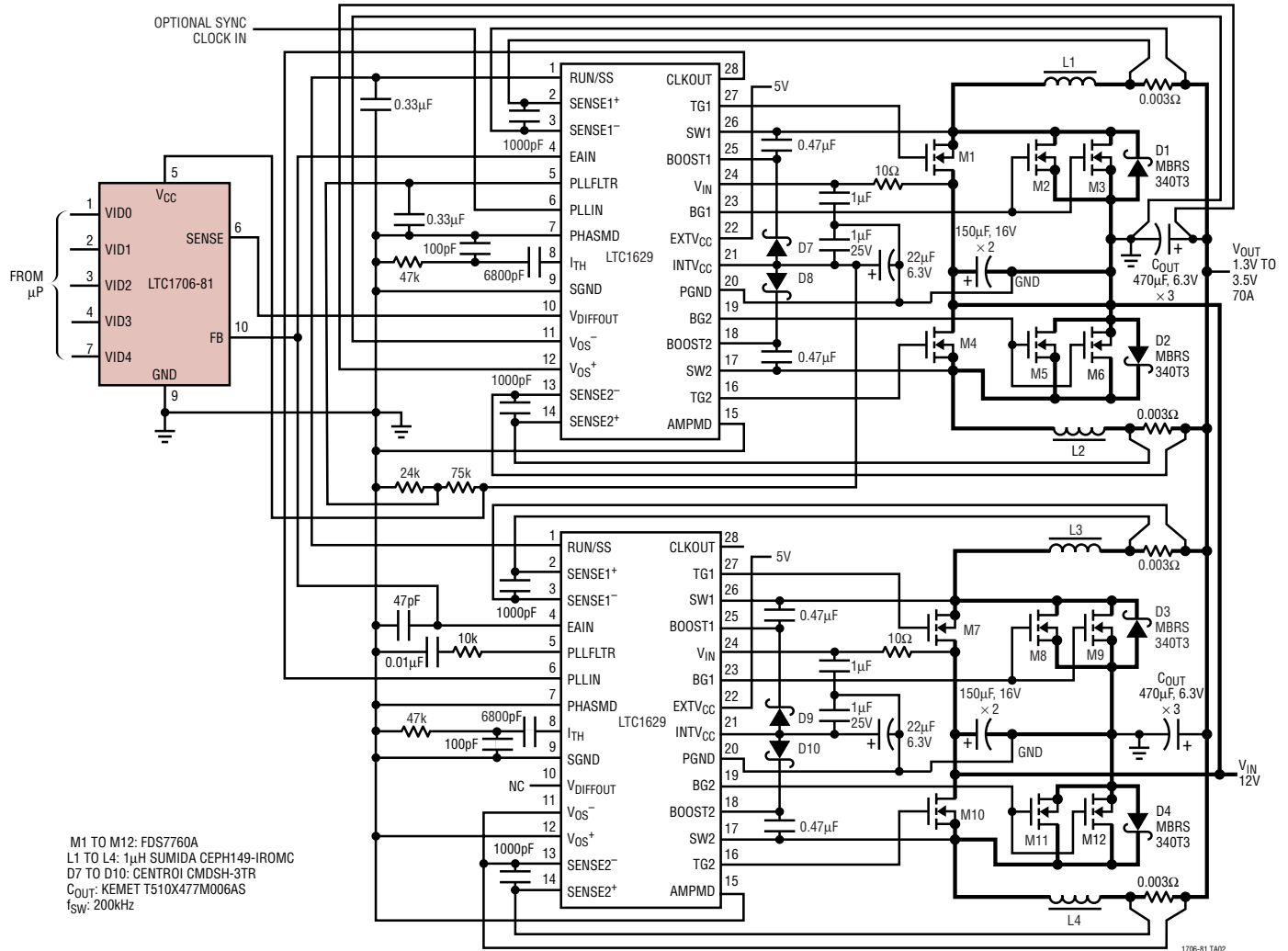


\* DIMENSION DOES NOT INCLUDE MOLD FLASH, PROTRUSIONS OR GATE BURRS. MOLD FLASH, PROTRUSIONS OR GATE BURRS SHALL NOT EXCEED 0.006" (0.152mm) PER SIDE

\*\* DIMENSION DOES NOT INCLUDE INTERLEAD FLASH OR PROTRUSIONS. INTERLEAD FLASH OR PROTRUSIONS SHALL NOT EXCEED 0.006" (0.152mm) PER SIDE

# TYPICAL APPLICATION

## VID Controlled High Current 70A 4-Phase Application



M1 TO M12: FDS7760A  
 L1 TO L4: 1μH SUMIDA CEPH149-IROMC  
 D7 TO D10: CENTROI CMDSH-3TR  
 C<sub>OUT</sub>: KEMET T510X477M006AS  
 f<sub>sw</sub>: 200kHz

## RELATED PARTS

PART NUMBER	DESCRIPTION	COMMENTS
LTC1622	Low Voltage Step-Down Controller	8-Pin MSOP, $2V \leq V_{IN} \leq 10V$ , 550kHz, Burst Mode™ Operation
LTC1628	Dual High Efficiency, 2-Phase Synchronous Step-Down Controller	Constant, Standby, 5V and 3.3V LDOs, $3.5V \leq V_{IN} \leq 36V$
LTC1629	PolyPhase™ High Efficiency Step-Down DC/DC Controller	Expandable Up to 12 Phases, Up to 120A, Remote Sense Diff Amp
LTC1702/LTC1703	Dual High Efficiency, 2-Phase Synchronous Step-Down Controller	550kHz, 25MHz GBW, No R <sub>SENSE</sub> ™, $2.7V \leq V_{IN} \leq 7V$
LTC1709	2-Phase Synchronous Step-Down Controller with 5-Bit VID	$4V \leq V_{IN} \leq 36V$ , PLL, 36-Pin SSOP, Current Mode Operation
LTC1735	High Efficiency Synchronous Step-Down Controller	Burst Mode Operation, 16-Pin Narrow SSOP, Fault Protection, $3.5V \leq V_{IN} \leq 36V$
LTC1736	High Efficiency Synchronous Step-Down Controller with 5-Bit 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, $2V \leq V_{IN} \leq 10V$ , 550kHz, Burst Mode Operation
LTC1929	2-Phase Synchronous Step-Down Controller	Current Mode Operation, I <sub>OUT</sub> Up to 40A, $3.5V \leq V_{IN} \leq 36V$

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