



LTC1706-61

## 5-Bit VID Voltage Programmer for AMD Opteron CPUs

### FEATURES

- Programs Regulator Output Voltage Range from 0.8V to 1.55V in 25mV Steps
- Programs a Wide Range of Linear Technology DC/DC Converters with a 0.6V Reference
- $\pm 0.35\%$  Accurate Output Voltage
- Built-In 40k Pull-Up Resistors on VID Inputs
- Available in MSOP-10 Package

### APPLICATIONS

- AMD Opteron™ Processor Power Supply
- Workstations and Servers
- Large Memory Array Supply

### DESCRIPTION

The LTC®1706-61 is a precision, digitally programmed, resistive ladder which adjusts the output of any 0.6V referenced regulator. Depending on the state of the five VID inputs, an output voltage between 0.8V and 1.55V is programmed in 25mV increments.

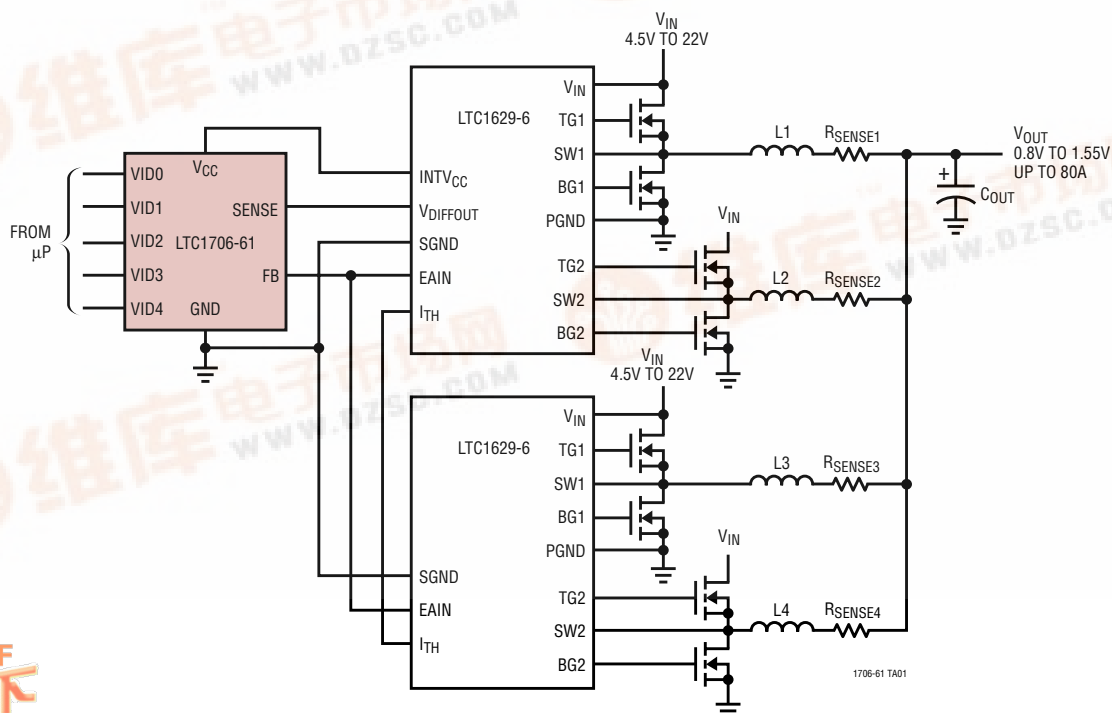
The LTC1706-61 is designed specifically to program an entire family of Linear Technology DC/DC converters with on board 0.6V references.

The LTC1706-61 programs the following Linear Technology DC/DC converter products: LTC1629-6, LTC3714, LTC3731 and LTC3778. (Consult factory for additional DC/DC converter products.)

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### TYPICAL APPLICATION

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



## 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 Ambient Temperature Range

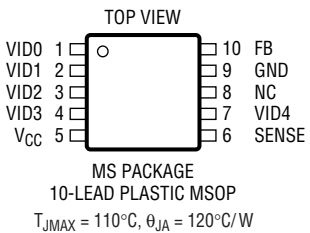
(Note 2) ..... –40°C to 85°C

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-61     |
|                                                                                    | MS PART MARKING   |
|                                                                                    | LTK9              |

Consult LTC Marketing for parts specified with wider operating temperature ranges.

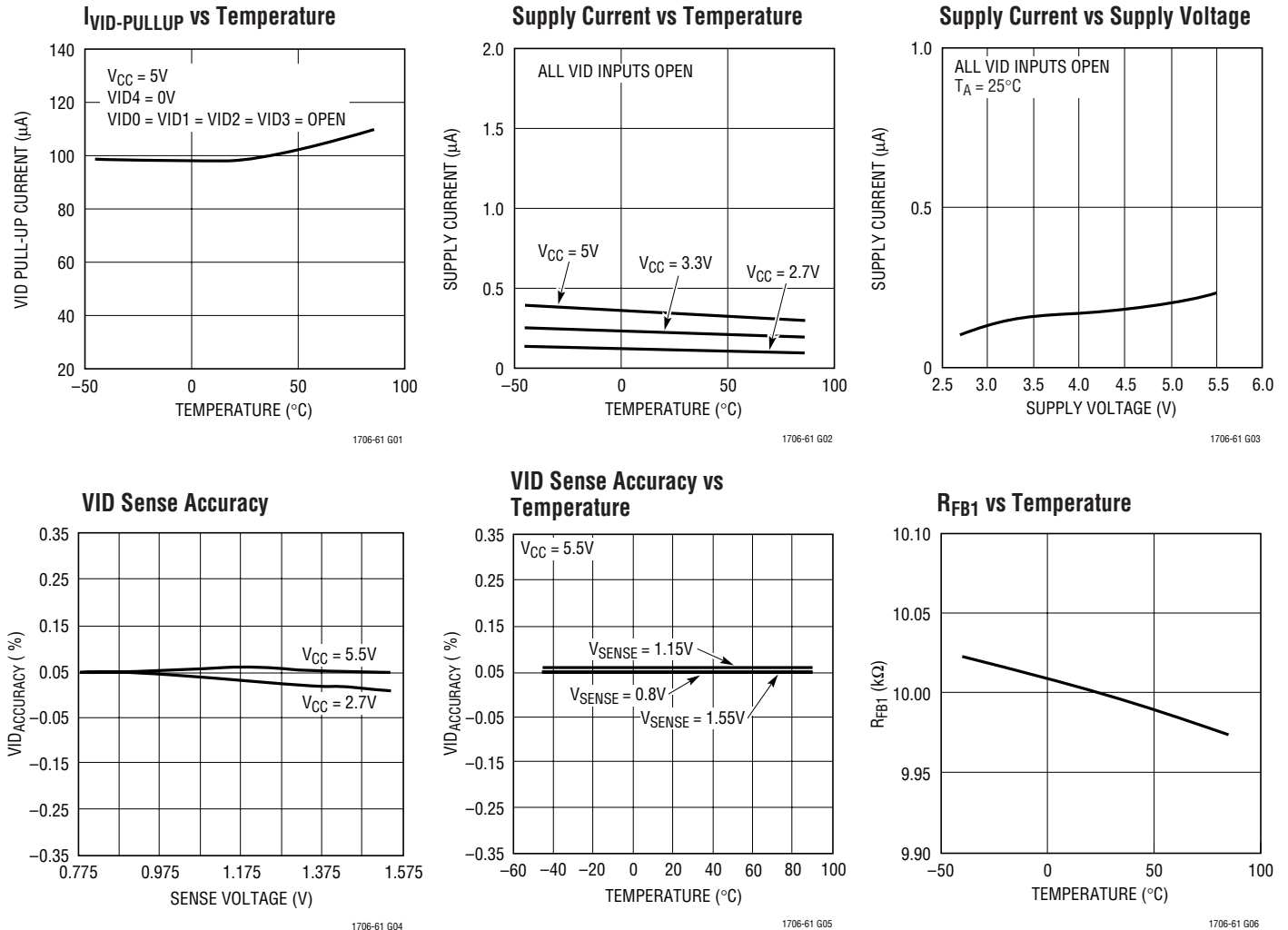
## ELECTRICAL CHARACTERISTICS

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       | $\mu\text{A}$    |
| $R_{FB-SENSE}$    | Resistance Between SENSE and FB |                                                                                                            | ● 6     | 10   | 14      | $\text{k}\Omega$ |
| $V_{OUT}$ Error % | Output Voltage Accuracy         |                                                                                                            | ● –0.35 |      | +0.35   | %                |
| $R_{PULLUP}$      | VID Input Pull-Up Resistance    | $V_{DIODE} = 0.6\text{V}$ (Note 4)                                                                         |         | 40   |         | $\text{k}\Omega$ |
| $\text{VID}_{TH}$ | VID Input Voltage Threshold     | $V_{IL} (2.7\text{V} \leq V_{CC} \leq 5.5\text{V})$<br>$V_{IH} (2.7\text{V} \leq V_{CC} \leq 5.5\text{V})$ |         | 1.6  | 0.4     | V                |
| $I_{VID-LEAK}$    | VID Input Leakage Current       | $V_{CC} < \text{VID} < 7\text{V}$ (Note 4)                                                                 |         | 0.01 | $\pm 1$ | $\mu\text{A}$    |
| $V_{PULLUP}$      | VID Pull-Up Voltage             | $V_{CC} = 3.3\text{V}$<br>$V_{CC} = 5\text{V}$                                                             |         | 2.8  | 4.5     | V                |

**Note 1:** Absolute Maximum Ratings are those values beyond which the life of a device may be impaired.**Note 2:** The LTC1706EMS-61 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



## PIN FUNCTIONS

**VID0 (Pin 1):** LSB Programming Input. Low = GND, High =  $V_{CC}$  or Float. Grounding VID0 adds 25mV to the output sense voltage.

**VID1 (Pin 2):** 4th MSB Programming Input. Low = GND, High =  $V_{CC}$  or Float. Grounding VID1 adds 50mV to the output sense voltage.

**VID2 (Pin 3):** 3rd MSB Programming Input. Low = GND, High =  $V_{CC}$  or Float. Grounding VID2 adds 100mV to the output sense voltage.

**VID3 (Pin 4):** 2nd MSB Programming Input. Low = GND, High =  $V_{CC}$  or Float. Grounding VID3 adds 200mV 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.

**VID4 (Pin 7):** MSB Programming Input. Low = GND, High =  $V_{CC}$  or Float. Grounding VID4 adds 400mV to the output sense voltage.

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

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

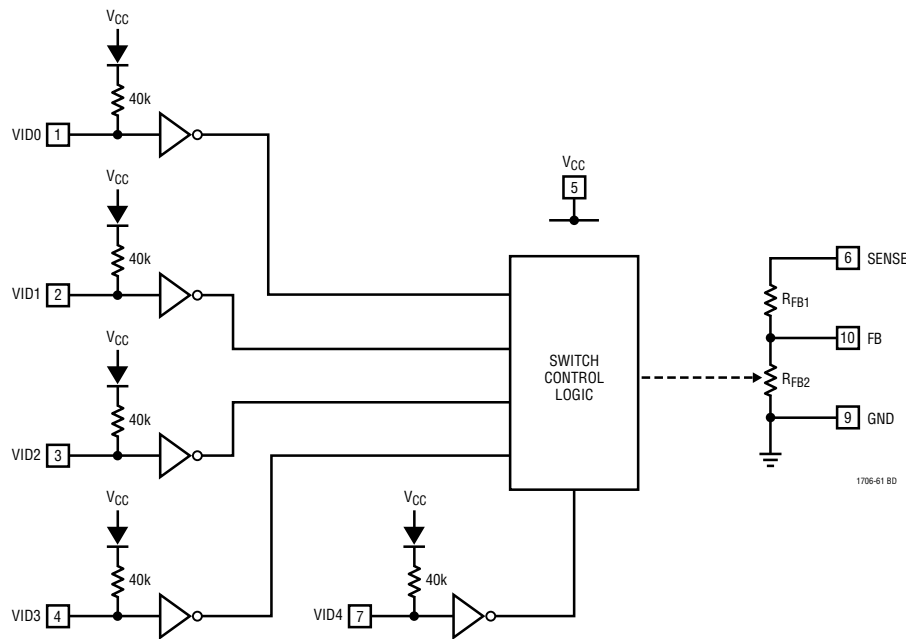
**FB (Pin 10):** Feedback Input. Connect to the 0.6V feedback pin of a compatible regulator.

# LTC1706-61

## PIN FUNCTIONS

| 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     | 4th MSB Programmable Input | 0           |     | $V_{CC}$ | -0.3             | 7   |
| 3   | VID2     | 3rd MSB Programmable Input | 0           |     | $V_{CC}$ | -0.3             | 7   |
| 4   | VID3     | 2nd 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   |             |     | 1.55     | -0.3             | 7   |
| 7   | VID4     | 1st MSB Programmable Input | 0           |     | $V_{CC}$ | -0.3             | 7   |
| 8   | NC       |                            |             |     |          |                  |     |
| 9   | GND      | Ground                     |             | 0   |          | -0.3             | 7   |
| 10  | FB       | 0.6V Feedback Input        | 0           | 0.6 | 1.5      | -0.3             | 7   |

## BLOCK DIAGRAM



## OPERATION

The LTC1706-61 is a precision resistive divider designed specifically for use with an entire family of Linear Technology Corporation DC/DC switching regulators with 0.6V internal reference and feedback voltage. The LTC1706-61 produces an output voltage ranging from 0.8V to 1.55V in 25mV 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<sub>FB1</sub>, connected between SENSE and FB, is typically 10k and is not modified by the state of the VID program inputs.

The “bottom” feedback resistor, R<sub>FB2</sub>, however, is modified by the five VID inputs and is precisely ratioed to R<sub>FB1</sub>.

## OPERATION

### 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.

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

| CODE  | VID4  | VID3  | VID2  | VID1  | VID0  | OUTPUT  |
|-------|-------|-------|-------|-------|-------|---------|
| 00000 | GND   | GND   | GND   | GND   | GND   | 1.550V  |
| 00001 | GND   | GND   | GND   | GND   | Float | 1.525V  |
| 00010 | GND   | GND   | GND   | Float | GND   | 1.500V  |
| 00011 | GND   | GND   | GND   | Float | Float | 1.475V  |
| 00100 | GND   | GND   | Float | GND   | GND   | 1.450V  |
| 00101 | GND   | GND   | Float | GND   | Float | 1.425V  |
| 00110 | GND   | GND   | Float | Float | GND   | 1.400V  |
| 00111 | GND   | GND   | Float | Float | Float | 1.375V  |
| 01000 | GND   | Float | GND   | GND   | GND   | 1.350V  |
| 01001 | GND   | Float | GND   | GND   | Float | 1.325V  |
| 01010 | GND   | Float | GND   | Float | GND   | 1.300V  |
| 01011 | GND   | Float | GND   | Float | Float | 1.275V  |
| 01100 | GND   | Float | Float | GND   | GND   | 1.250V  |
| 01101 | GND   | Float | Float | GND   | Float | 1.225V  |
| 01110 | GND   | Float | Float | Float | GND   | 1.200V  |
| 01111 | GND   | Float | Float | Float | Float | 1.175V  |
| 10000 | Float | GND   | GND   | GND   | GND   | 1.150V  |
| 10001 | Float | GND   | GND   | GND   | Float | 1.125V  |
| 10010 | Float | GND   | GND   | Float | GND   | 1.100V  |
| 10011 | Float | GND   | GND   | Float | Float | 1.075V  |
| 10100 | Float | GND   | Float | GND   | GND   | 1.050V  |
| 10101 | Float | GND   | Float | GND   | Float | 1.025V  |
| 10110 | Float | GND   | Float | Float | GND   | 1.000V  |
| 10111 | Float | GND   | Float | Float | Float | 0.975V  |
| 11000 | Float | Float | GND   | GND   | GND   | 0.950V  |
| 11001 | Float | Float | GND   | GND   | Float | 0.925V  |
| 11010 | Float | Float | GND   | Float | GND   | 0.900V  |
| 11011 | Float | Float | GND   | Float | Float | 0.875V  |
| 11100 | Float | Float | Float | GND   | GND   | 0.850V  |
| 11101 | Float | Float | Float | GND   | Float | 0.825V  |
| 11110 | Float | Float | Float | Float | GND   | 0.800V  |
| 11111 | Float | Float | Float | Float | Float | *0.775V |

\*Represents codes without a defined output (shutdown) voltage as specified in AMD specifications. The LTC1706-61 interprets these codes as a valid input and produces an output voltage as follows: (11111) = 0.775V.

When all five VID inputs are high or floating, such as when no CPU is present in a system, a regulated 0.775V 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 LTC1629-6, the LTC1706-61's FB, SENSE,  $V_{CC}$  and GND pins should be connected, respectively, with the EAIN,  $V_{DIFFOUT}$ ,  $INTV_{CC}$  and SGND pins of the LTC1629-6. The result of this application is a precisely controlled, variable output voltage supply to any low voltage, high current system such as a powerful personal computer, workstation or network server.

### 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 LTC1706-61 to be fully logic compatible and operational over a higher input voltage range (less than the 7V absolute maximum rating).

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 $\Omega$ .

# LTC1706-61

## OPERATION

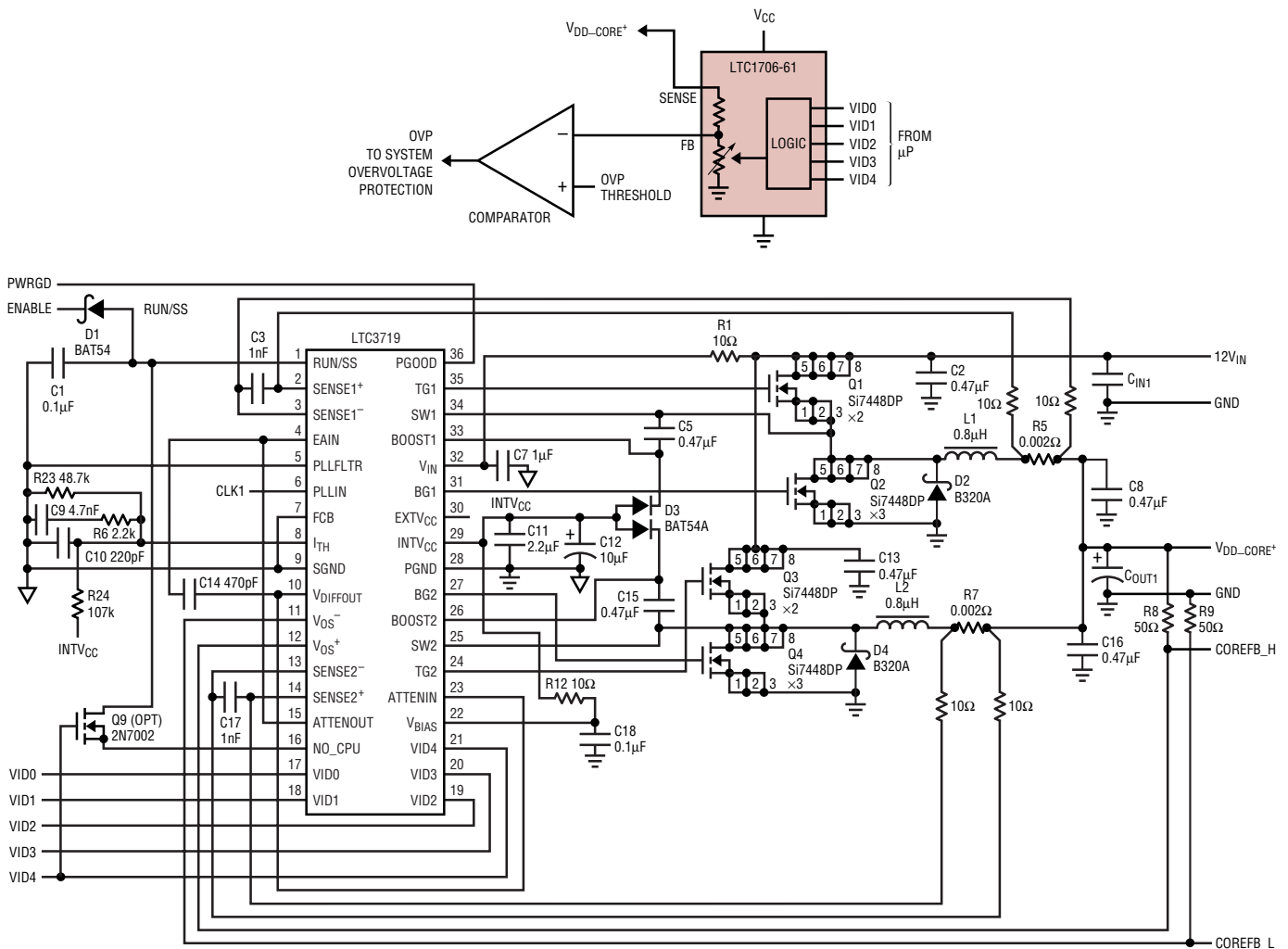
In other words, each VID input has a typical pull-up current of 68 $\mu$ A for a 3.3V system.

Besides the LTC1629-6, the LTC1706-61 also programs a whole family of LTC DC/DC converters that have an onboard

0.6V reference. The LTC3714, LTC3778 and LTC3731 are just a few of the high efficiency step-down switching regulators that will work equally well with the LTC1706-61.

## TYPICAL APPLICATION

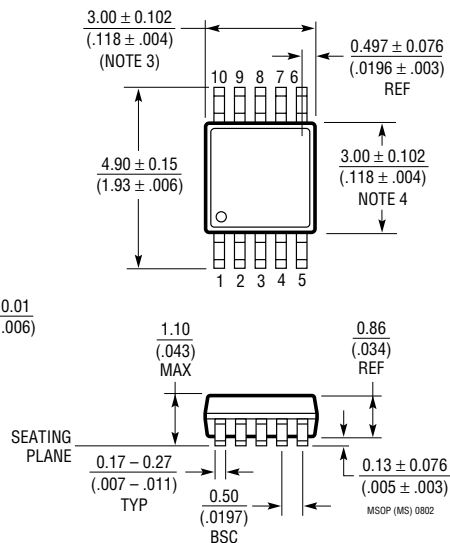
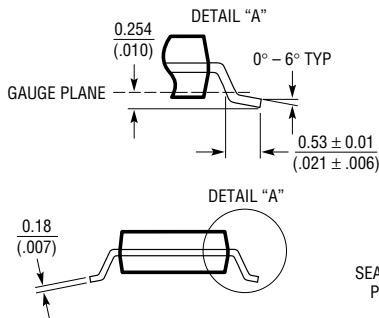
### 2-Phase 12V Input, 0.8V to 1.55V/45A Max Power Supply with Adjustable Overvoltage Protection



C<sub>IN1</sub>: SIX 10 $\mu$ F 16V CERAMIC CAPACITORS  
C<sub>OUT1</sub>: TEN 22 $\mu$ F 6.3V CERAMIC CAPACITORS  
L1, L2: SUMIDA CEP125-1R0MC-H

1706-61 TA03

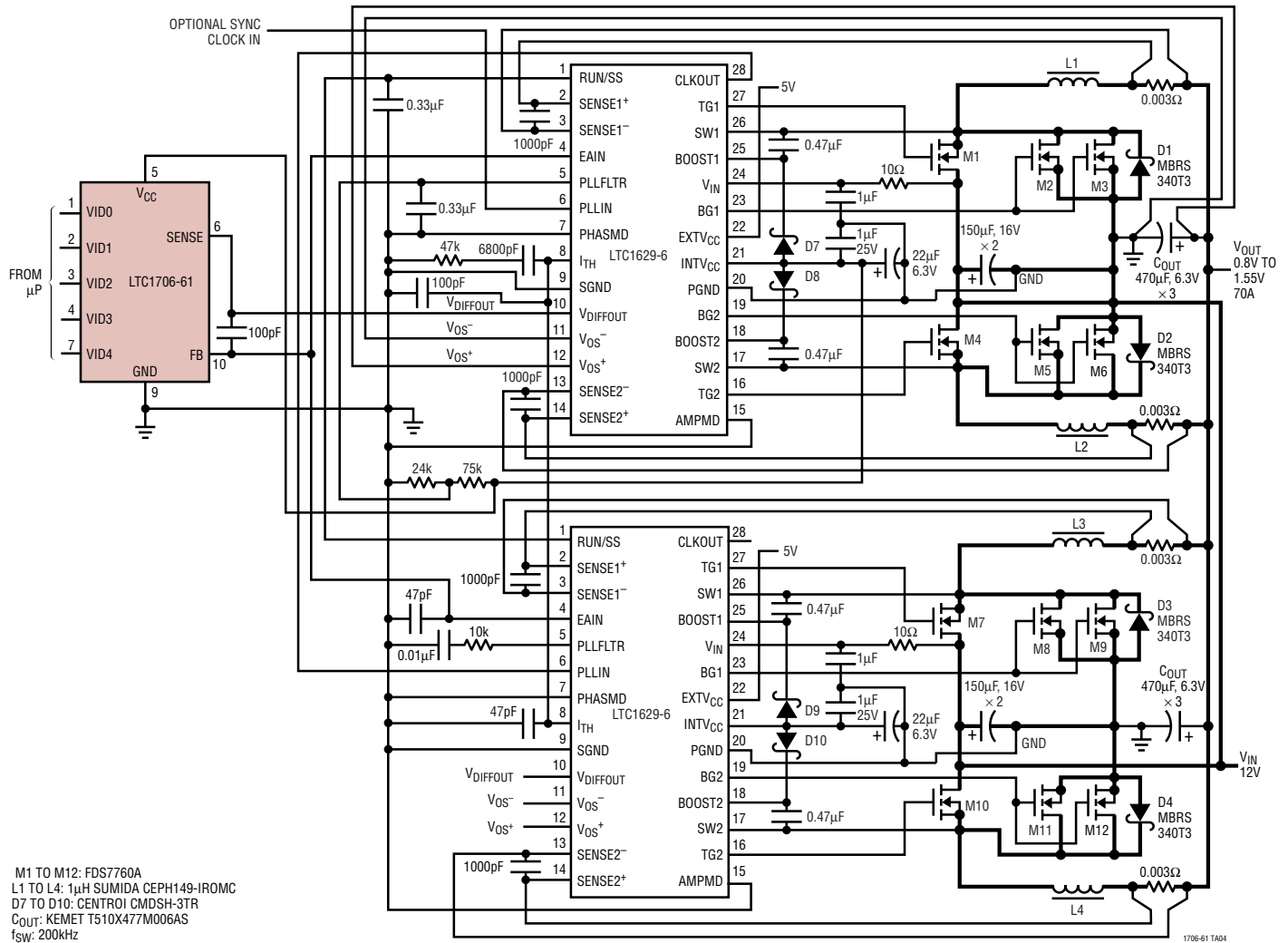
## PACKAGE DESCRIPTION



- 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

## TYPICAL APPLICATION

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



## RELATED PARTS

| PART NUMBER | DESCRIPTION                                                              | COMMENTS                                                                                                                              |
|-------------|--------------------------------------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------|
| LTC1629-6   | PolyPhase® Synchronous Step-Down Controller                              | Up to 12-Phase Operation, Up to 200A Power Supply                                                                                     |
| LTC3714     | Single Phase Synchronous Step-Down Controller with VID                   | $0.6V \leq V_{OUT} \leq 1.75V$ , $I_{OUT} \leq 25A$                                                                                   |
| LTC3716     | 2-Phase Synchronous Step-Down Controller with VID                        | $0.6V \leq V_{OUT} \leq 1.75V$ , $I_{OUT} \leq 40A$                                                                                   |
| LTC3719     | AMD Opteron CPU Power Supply                                             | $0.8V \leq V_{OUT} \leq 1.55V$ , $I_{OUT} \leq 40A$                                                                                   |
| LTC3731     | 3-Phase, 60A Synchronous Step-Down Controller                            | Single IC 60A Solution with Onboard MOSFET Drivers, $\pm 5\%$ Output Current Matching for Optimum Thermal Performance and Reliability |
| LTC3733     | 3-Phase, 60A Synchronous Step-Down Controller for AMD Opteron Processors | On-Board VID and MOSFET Drivers, $0.8V \leq V_{OUT} \leq 1.55V$ , $I_{OUT} \leq 60A$                                                  |
| LTC3778     | Optional R <sub>SENSE</sub> Synchronous Step-Down Controller             | $4V \leq V_{IN} \leq 36V$ , $0.6V \leq V_{OUT} \leq (0.9)V_{IN}$ , $I_{OUT} \leq 25A$                                                 |

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