

# 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.

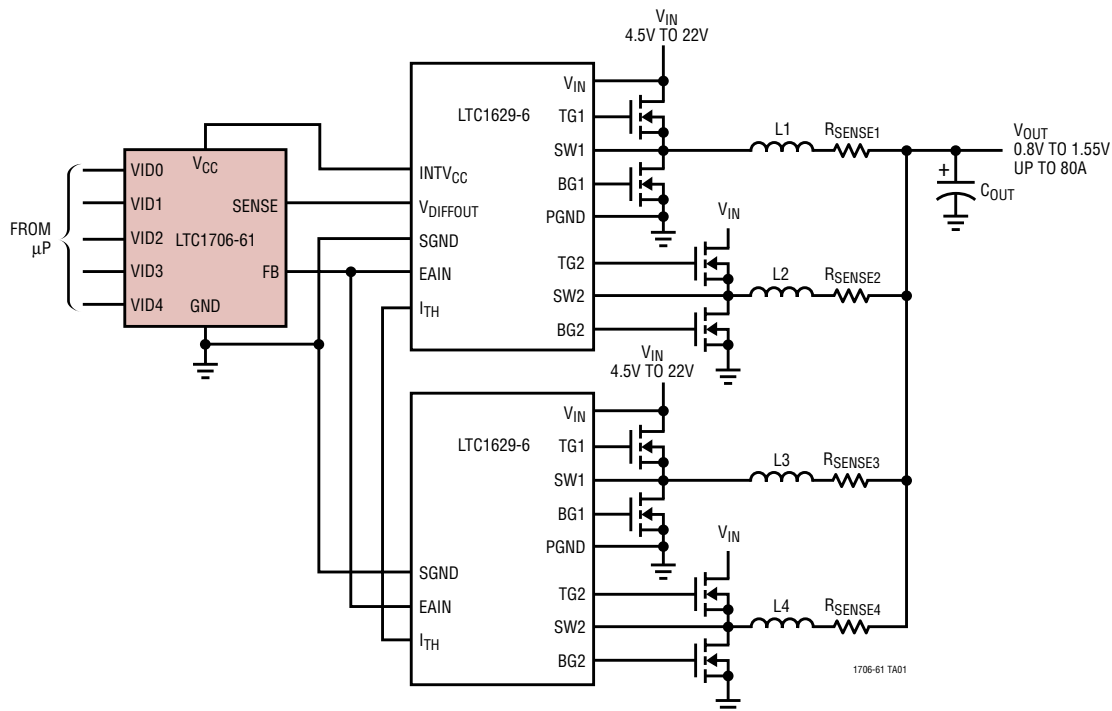
The LTC1706-61 is designed specifically to program an entire family of Linear Technology DC/DC converters with on board 0.6V references.

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)



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## 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	$\mu\text{A}$
$R_{\text{FB-SENSE}}$	Resistance Between SENSE and FB		● 6	10	14	$\text{k}\Omega$
$V_{\text{OUT Error \%}}$	Output Voltage Accuracy		● -0.35		+0.35	%
$R_{\text{PULLUP}}$	VID Input Pull-Up Resistance	$V_{\text{DIODE}} = 0.6\text{V}$ (Note 4)		40		$\text{k}\Omega$
$V_{\text{IDTH}}$	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.

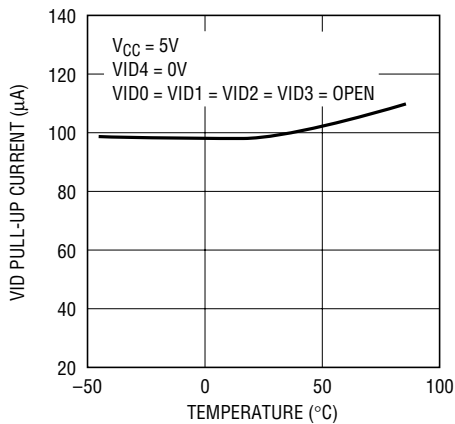
**Note 2:** The LTC1706EMS-61 is guaranteed to meet performance specifications from 0°C to 70°C. Specifications over the -40°C to 85°C operating temperature range are assured by design, characterization and correlation with statistical process controls.

**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.)

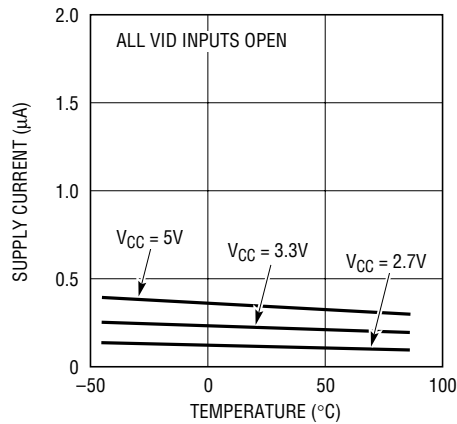
## TYPICAL PERFORMANCE CHARACTERISTICS

### VID-PULLUP vs Temperature



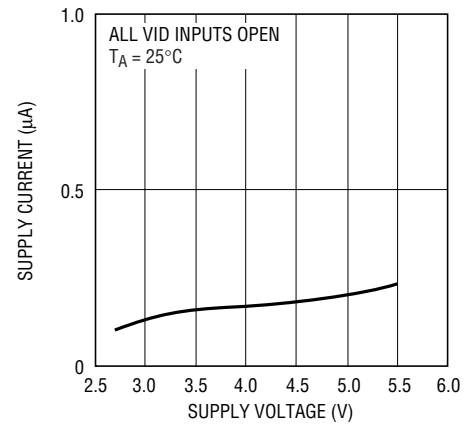
1706-61 G01

### Supply Current vs Temperature



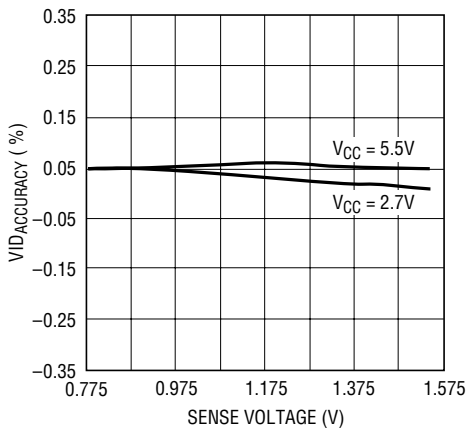
1706-61 G02

### Supply Current vs Supply Voltage



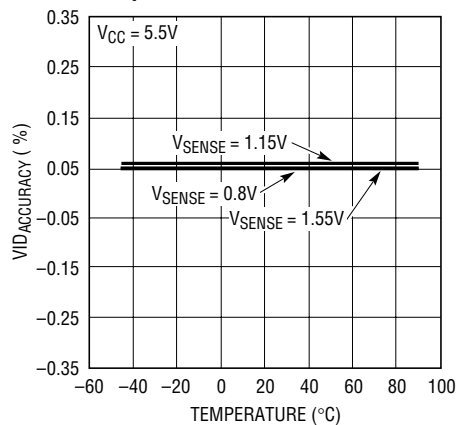
1706-61 G03

### VID Sense Accuracy



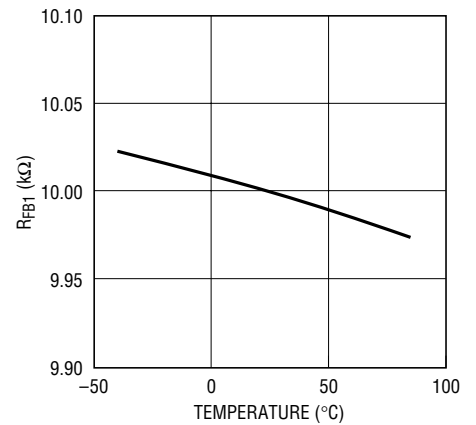
1706-61 G04

### VID Sense Accuracy vs Temperature



1706-61 G05

### R<sub>FB1</sub> vs Temperature



1706-61 G06

## 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.

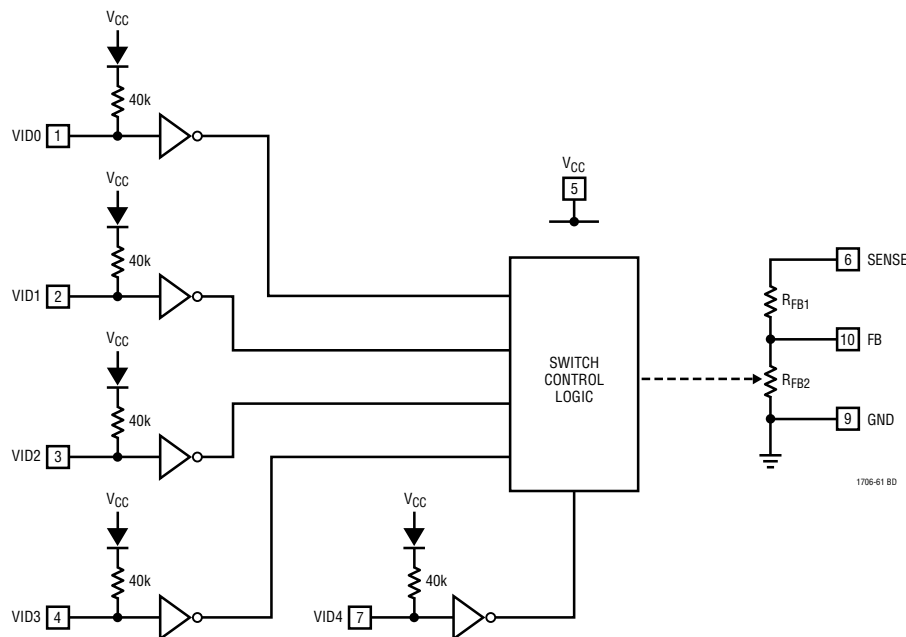
**FB (Pin 10):** Feedback Input. Connect to the 0.6V feedback pin of a compatible regulator.

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## 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	0.8		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,  $R_{FB1}$ , connected between SENSE and FB, is typically 10k and is not modified by the state of the VID program inputs.

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

## 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,  $V_{DIFFOUT}$ , INT $V_{CC}$  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 $\Omega$ .

## OPERATION

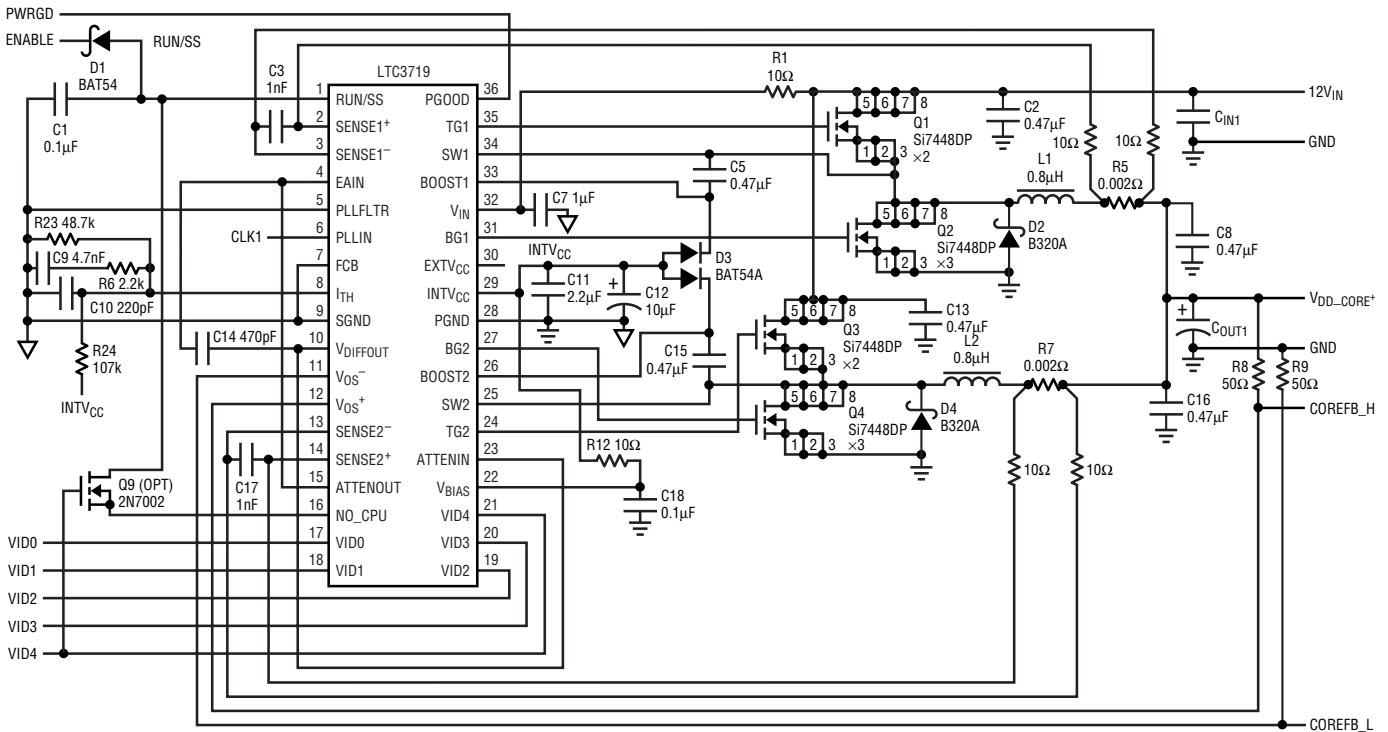
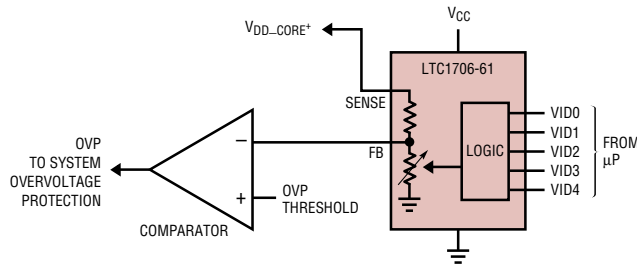
In other words, each VID input has a typical pull-up current of 68 $\mu$ A for a 3.3V system.

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



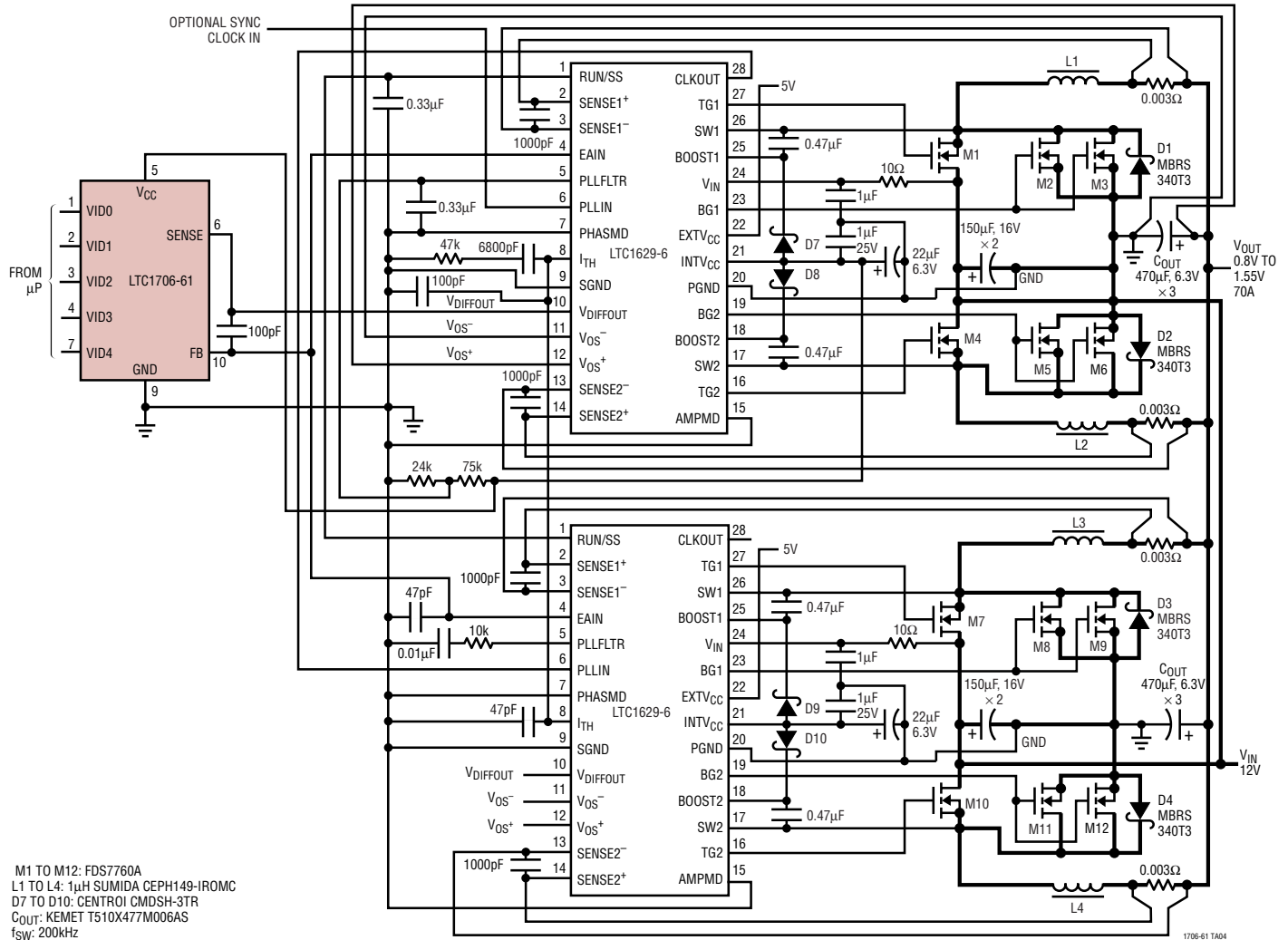
C<sub>IN1</sub>: SIX 10 $\mu$ F 16V CERAMIC CAPACITORS  
 C<sub>OUT1</sub>: TEN 22 $\mu$ F 6.3V CERAMIC CAPACITORS  
 L1, L2: SUMIDA CEP125-1R0MC-H

1706-61 TA03



# TYPICAL APPLICATION

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



## RELATED PARTS

PART NUMBER	DESCRIPTION	COMMENTS
LTC1629-6	PolyPhase <sup>®</sup> 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 ≤ V <sub>OUT</sub> ≤ 1.75V, I <sub>OUT</sub> ≤ 25A
LTC3716	2-Phase Synchronous Step-Down Controller with VID	0.6V ≤ V <sub>OUT</sub> ≤ 1.75V, I <sub>OUT</sub> ≤ 40A
LTC3719	AMD Opteron CPU Power Supply	0.8V ≤ V <sub>OUT</sub> ≤ 1.55V, I <sub>OUT</sub> ≤ 40A
LTC3731	3-Phase, 60A Synchronous Step-Down Controller	Single IC 60A Solution with Onboard MOSFET Drivers, ±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 ≤ V <sub>OUT</sub> ≤ 1.55V, I <sub>OUT</sub> ≤ 60A
LTC3778	Optional R <sub>SENSE</sub> Synchronous Step-Down Controller	4V ≤ V <sub>IN</sub> ≤ 36V, 0.6V ≤ V <sub>OUT</sub> ≤ (0.9)V <sub>IN</sub> , I <sub>OUT</sub> ≤ 25A

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