

## 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

|                                                                                                                                                                   |                      |
|-------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------------|
| <p>TOP VIEW</p> <p>MS10 PACKAGE<br/>10-LEAD PLASTIC MSOP</p> <p><math>T_{JMAX} = 110^{\circ}\text{C}</math>, <math>\theta_{JA} = 120^{\circ}\text{C/W}</math></p> | ORDER PART NUMBER    |
|                                                                                                                                                                   | LTC1706EMS-81        |
|                                                                                                                                                                   | MS10<br>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              | $\mu\text{A}$    |
| $R_{FB-SENSE}$    | Resistance Between SENSE and FB |                                                                                                                    | ● 12               | 20         | 28             | $\text{k}\Omega$ |
| $V_{OUT}$ Error % | Output Voltage Accuracy         | Programmed from 1.3V to 2.05V ( $\text{VID4} = 0$ )<br>Programmed from 2.1V to 3.5V ( $\text{VID4} = 1$ )          | ● -0.25<br>● -0.35 |            | +0.25<br>+0.25 | %                |
| $R_{PULLUP}$      | 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<br>4.5 |                | V                |

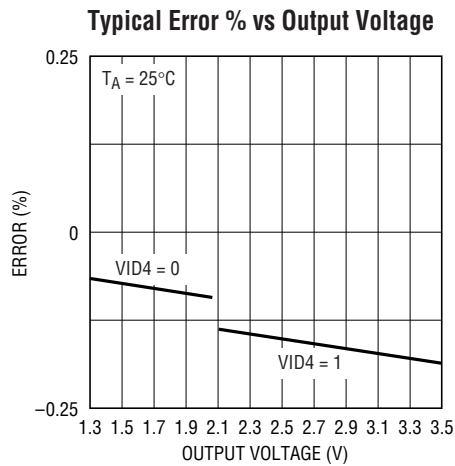
**Note 1:** Absolute Maximum Ratings are those values beyond which the life of a device may be impaired.

**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.

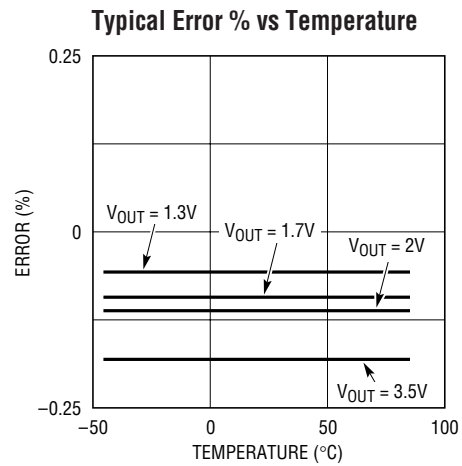
**Note 3:** With all five VID inputs floating, the  $V_{CC}$  supply current is simply the device leakage current. However, the  $V_{CC}$  supply current will rise and be approximately equal to the number of grounded VID input pins times  $(V_{CC} - 0.6\text{V})/40\text{k}$ . (See the VID Input Characteristics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

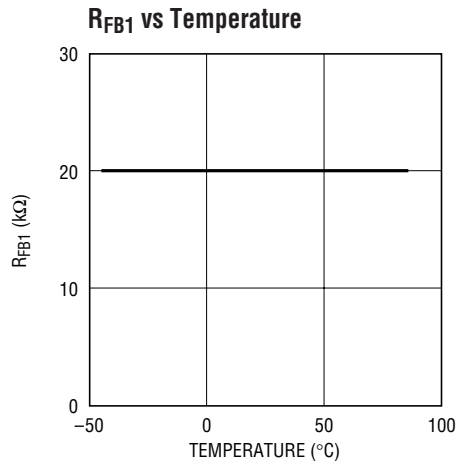
# TYPICAL PERFORMANCE CHARACTERISTICS



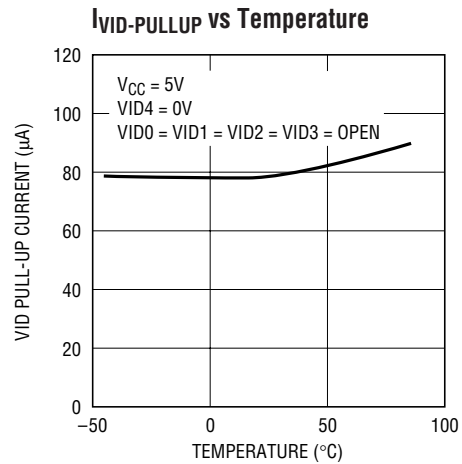
1706-81 G01



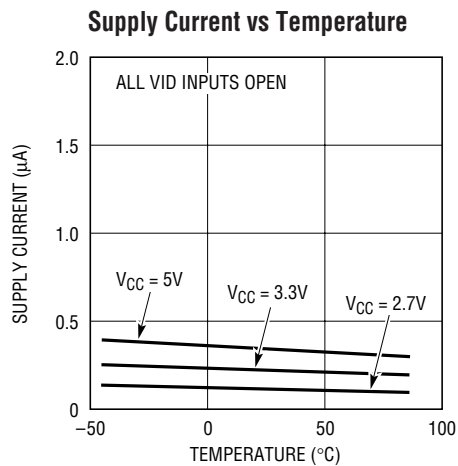
1706-81 G02



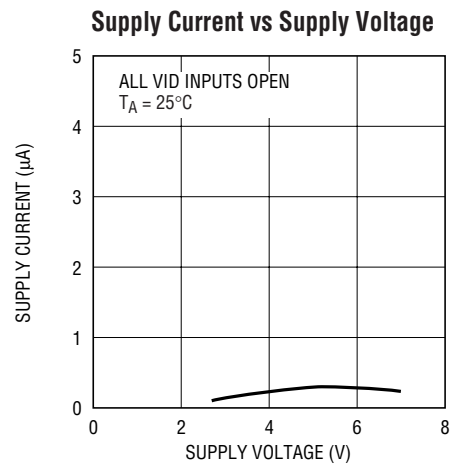
1706-81 G03



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.

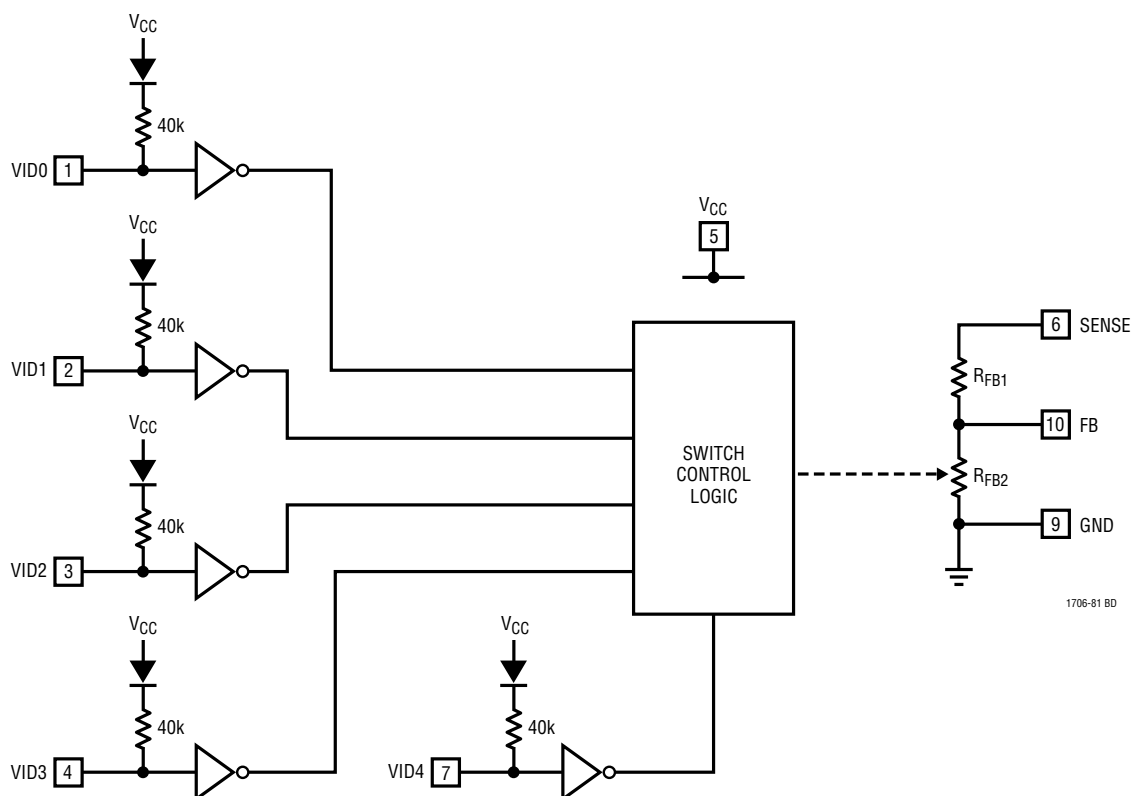
**NC (Pin 8):** No Connect.

**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



1706-81 BD

## 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,  $V_{DIFFOUT}$ , INTV $_{CC}$  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 $\Omega$ .

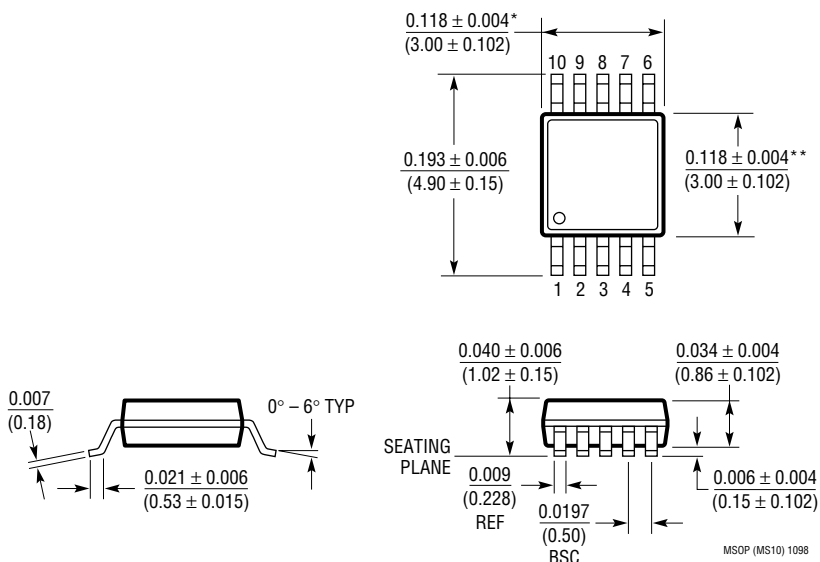
In other words, each VID input has a typical pull-up current of 68 $\mu$ A for a 3.3V system.

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)

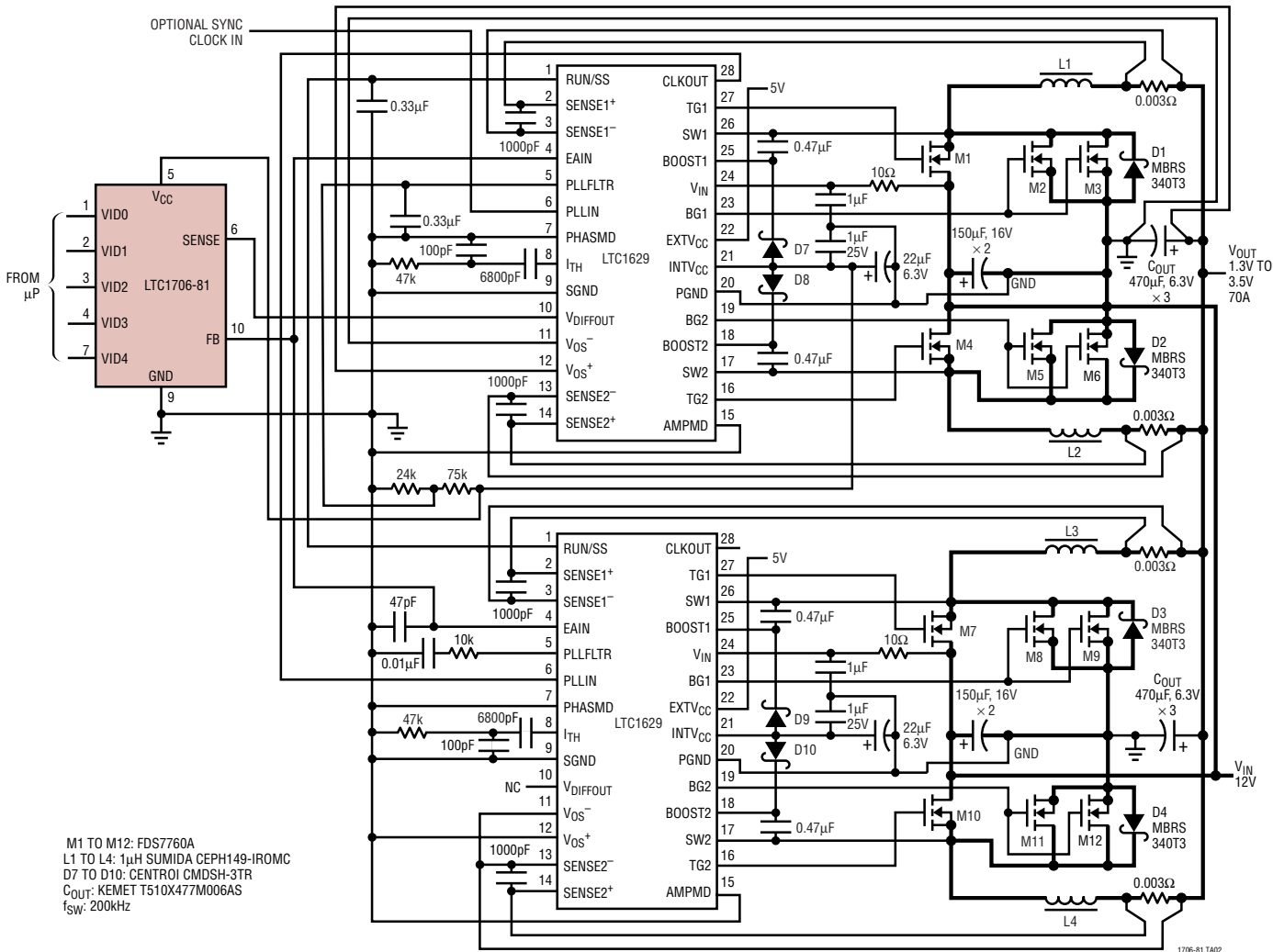


\* DIMENSION DOES NOT INCLUDE MOLD FLASH, PROTRUSIONS OR GATE BURRS. MOLD FLASH, PROTRUSIONS OR GATE BURRS SHALL NOT EXCEED 0.006" (0.152mm) PER SIDE

\*\* 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



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 $R_{SENSE}$ ™, $2.7V \leq V_{IN} \leq 7V$                         |
| 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, $I_{OUT}$ Up to 40A, $3.5V \leq V_{IN} \leq 36V$                |

Burst Mode, PolyPhase and No  $R_{SENSE}$  are trademarks of Linear Technology Corporation.