

FEATURES

- Fully Compliant with the Intel VRM9.0/9.1 VID Specification
- Programs Regulator Output Voltage from 1.10V to 1.85V in 25mV Steps
- Programs an Entire Family of Linear Technology DC/DC Converters
- $\pm 0.25\%$ Accurate Voltage Divider
- Built-In 40k Pull-Up Resistors on Program Inputs
- Available in MSOP-10 Packaging

APPLICATIONS

- Intel Pentium® III Processor Power Supply
- Multiprocessor Workstations and Servers
- Multiphase Processor Power Supply
- AMD Athlon™ Processor Power Supply

DESCRIPTION

The LTC®1706-82 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 1.10V and 1.85V is programmed in 25mV increments.

The LTC1706-82 is designed specifically to program an entire family of Linear Technology DC/DC converters in full compliance with the Intel VRM9.0/9.1 specifications.

The LTC1706-82 programs the following Linear Technology DC/DC converters: LTC1628, LTC1629, LTC1702, LTC1735, LTC1735-1, LTC1929 and LTC3729.

For a compact VRM9.0/9.1 solution with up to 60A capability, see the LTC3732, a 3-phase synchronous controller with integrated 5-bit VID and MOSFET drivers.

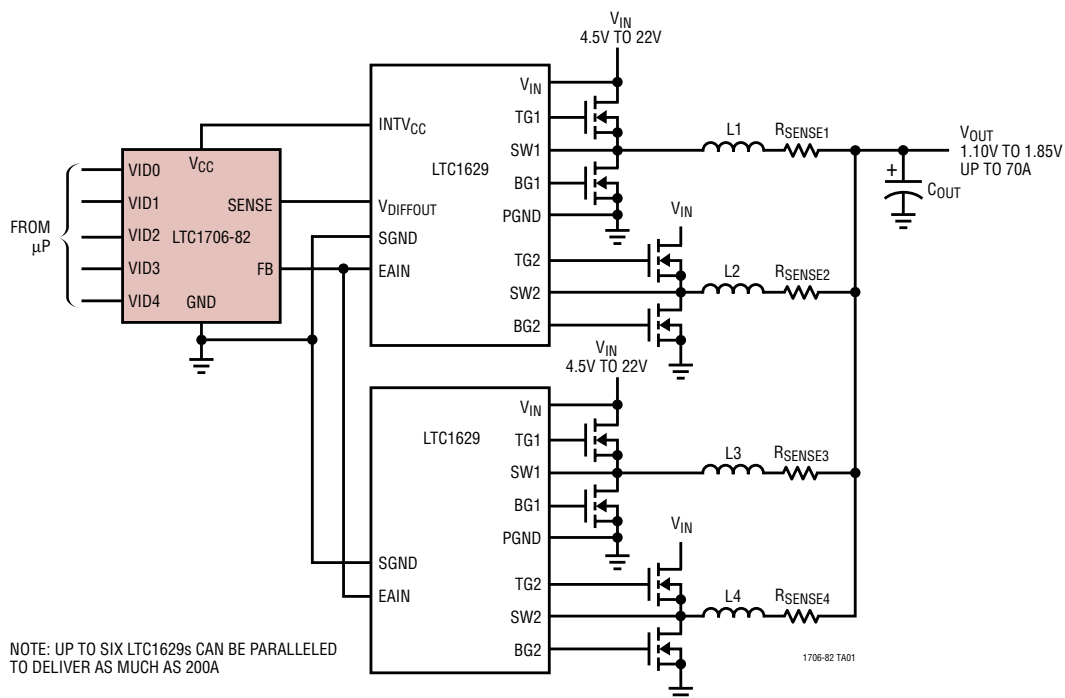
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TYPICAL APPLICATION

VID Controlled High Current 4-Phase DC/DC Converter (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 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-82 |
| | MS PART MARKING |
| | LTMJ |

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 $T_A = 25^\circ\text{C}$. $2.7\text{V} \leq V_{CC} \leq 5.5\text{V}$, $\text{VID0} = \text{VID1} = \text{VID2} = \text{VID3} = \text{VID4} = \text{NC}$ 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 | 5.0 | μA |
| $R_{\text{FB-SENSE}}$ | Resistance Between SENSE and FB | | ● 6 | 10 | 14 | $\text{k}\Omega$ |
| $V_{\text{OUT Error \%}}$ | Output Voltage Accuracy | Programmed From 1.10V to 1.85V | ● -0.25 | | 0.25 | % |
| R_{PULLUP} | VID Input Pull-Up Resistance | $V_{\text{DIODE}} = 0.6\text{V}$, (Note 4) | | 40 | | $\text{k}\Omega$ |
| VID_T | VID Input Voltage Threshold | $V_{\text{IL}} (2.7\text{V} < V_{CC} < 5.5\text{V})$ $V_{\text{IH}} (2.7\text{V} < V_{CC} < 5.5\text{V})$ | 1.6 | | 0.4 | V |
| $I_{\text{VID-LEAK}}$ | VID Input Leakage Current | $V_{CC} < \text{VID} < 7\text{V}$, (Note 4) | | 0.01 | ± 1.00 | μA |
| V_{PULLUP} | VID Pull-Up Voltage | $V_{CC} = 3.3\text{V}$ $V_{CC} = 5\text{V}$ | | 2.8 | 4.5 | V |

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

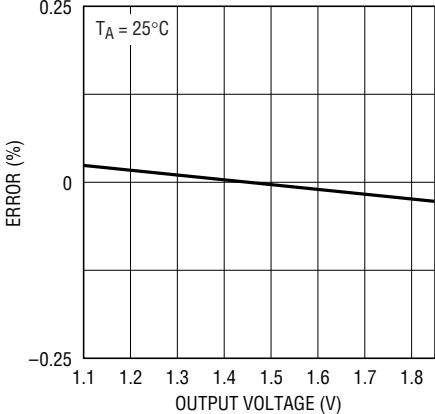
Note 2: The LTC1706-82 is guaranteed to meet performance specifications from 0°C to 70°C. Specifications over the -40°C to 85°C operating temperature range are assured by design, characterization and correlation with statistical process controls.

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 Applications Information section for more detail.)

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.)

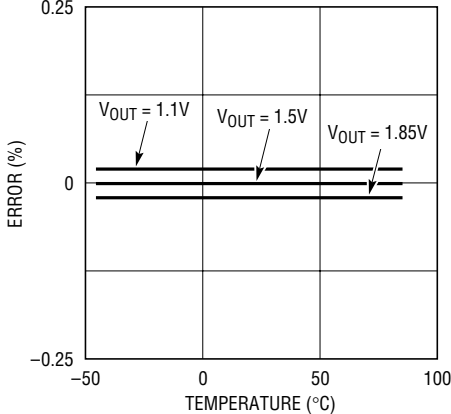
TYPICAL PERFORMANCE CHARACTERISTICS

Typical Error % vs Output Voltage



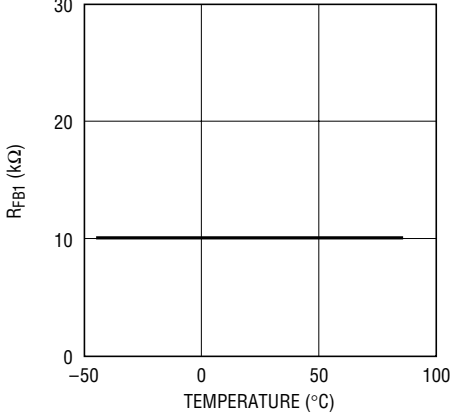
1706-82 G01

Typical Error % vs Temperature



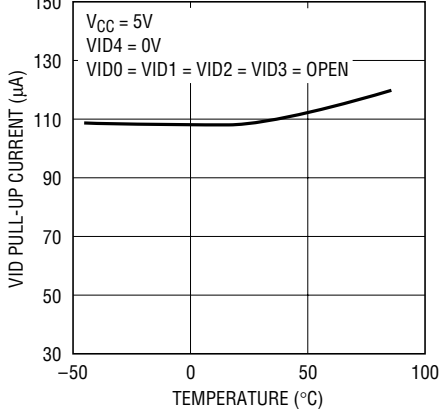
1706-82 G02

R_{FB1} vs Temperature



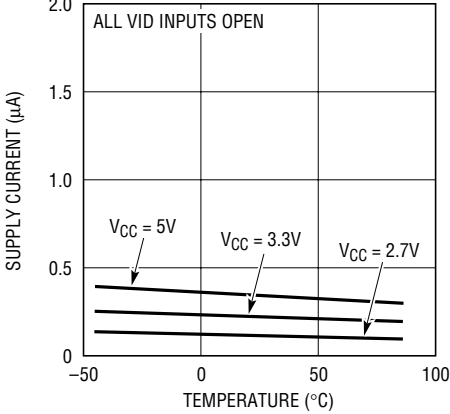
1706-82 G03

I_{VID-PULLUP} vs Temperature



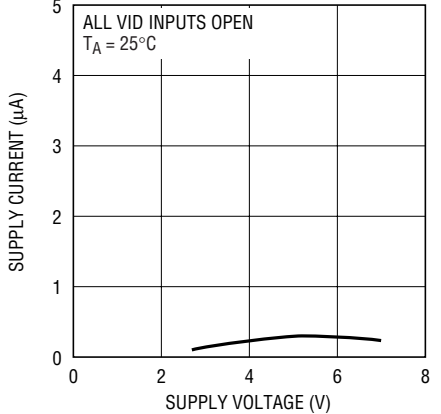
1706-82 G04

Supply Current vs Temperature



1706-82 G05

Supply Current vs Supply Voltage



1706-82 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 or $V_{DIFFOUT}$ when used with the LTC1629 and LTC1929.

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.

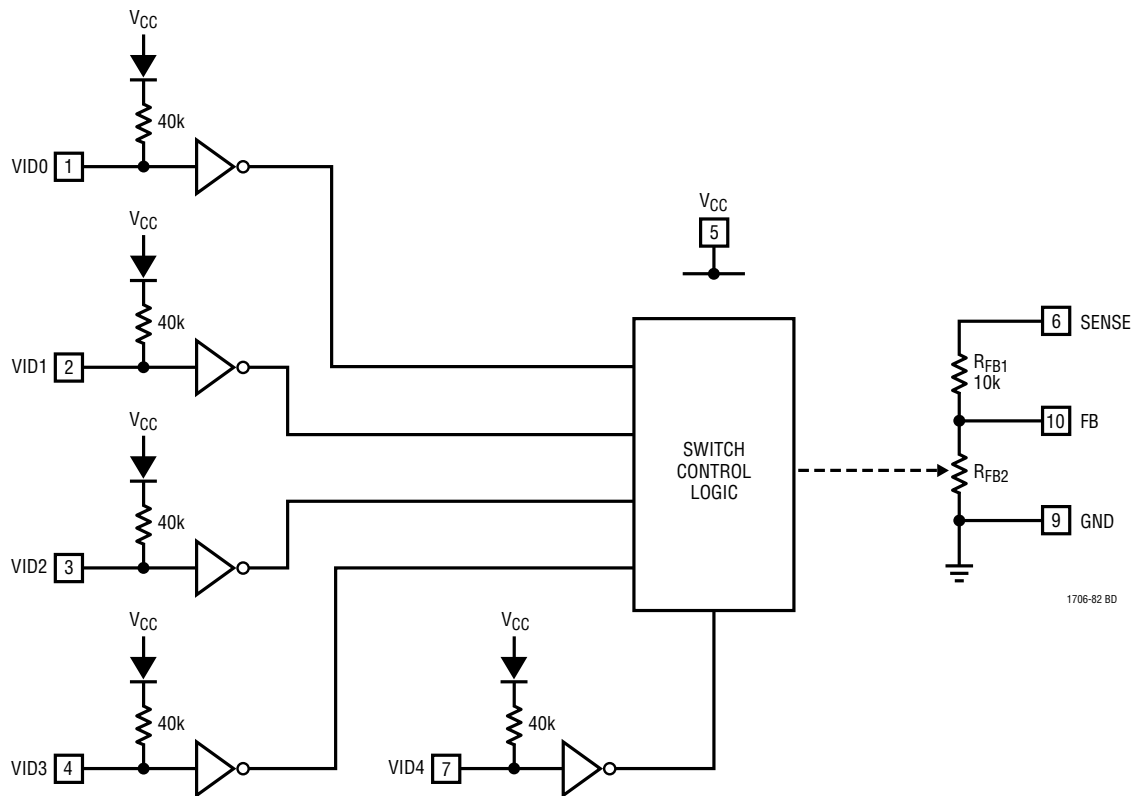
GND (Pin 9): Ground. Connect to regulator signal ground.

FB (Pin 10): Feedback Input. Connect to the 0.8V feedback pin of a compatible regulator or the EAIN pin of the LTC1629, LTC1929 and LTC3729.

PIN TABLE

| 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 | 1.075 | | 1.85 | -0.3 | 7 |
| 7 | VID4 | MSB 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 | 1.075 | -0.3 | 7 |

BLOCK DIAGRAM



1706-82 BD

OPERATION

The LTC1706-82 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 voltages. The LTC1706-82 produces an output voltage ranging from 1.10V to 1.85V 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} .

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 most significant bit (MSB) and VID0 is the least significant bit (LSB).

When the five VID inputs are low, or grounded, the regulator output voltage is set to 1.85V. Each increasing binary count is equivalent to a decrease of 25mV in the output voltage. Therefore, to obtain a 1.10V output, only VID0 is grounded while the other four VID inputs are tied high or floating.

When all five VID inputs are high or floating, such as when no CPU is present in a system, a regulated 1.075V output is generated at V_{SENSE} .

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OPERATION

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 be either 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, the LTC1706-82'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. 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 of the LTC1629 is also 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 LTC1706-82 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 VID 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 pullup resistance of 40k.

In other words, each VID input has a typical pull up current of $(V_{CC} - 0.6)/40K$, which is approximately 68 μ A for a 3.3V system.

Table 1. VID Inputs and Corresponding Output Voltage

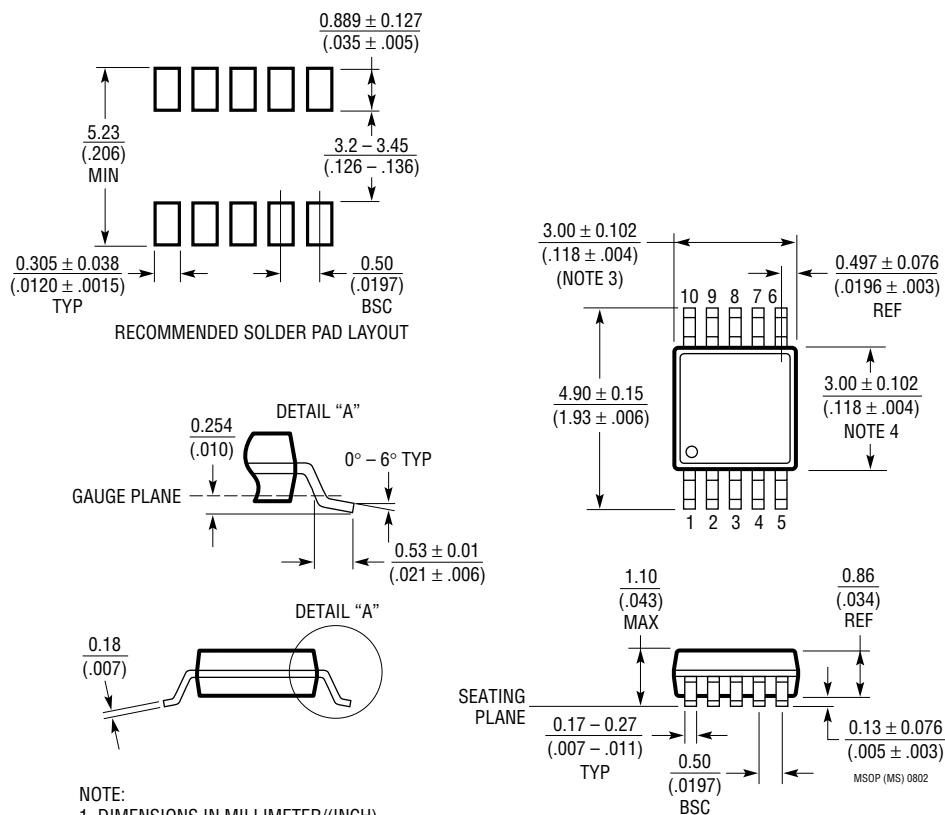
| CODE | VID4 | VID3 | VID2 | VID1 | VID0 | OUTPUT |
|-------|-------|-------|-------|-------|-------|--------------------|
| 00000 | GND | GND | GND | GND | GND | 1.850 |
| 00001 | GND | GND | GND | GND | Float | 1.825 |
| 00010 | GND | GND | GND | Float | GND | 1.800 |
| 00011 | GND | GND | GND | Float | Float | 1.775V |
| 00100 | GND | GND | Float | GND | GND | 1.750V |
| 00101 | GND | GND | Float | GND | Float | 1.725V |
| 00110 | GND | GND | Float | Float | GND | 1.700V |
| 00111 | GND | GND | Float | Float | Float | 1.675V |
| 01000 | GND | Float | GND | GND | GND | 1.650V |
| 01001 | GND | Float | GND | GND | Float | 1.625V |
| 01010 | GND | Float | GND | Float | GND | 1.600V |
| 01011 | GND | Float | GND | Float | Float | 1.575V |
| 01100 | GND | Float | Float | GND | GND | 1.550V |
| 01101 | GND | Float | Float | GND | Float | 1.525V |
| 01110 | GND | Float | Float | Float | GND | 1.500V |
| 01111 | GND | Float | Float | Float | Float | 1.475V |
| 10000 | Float | GND | GND | GND | GND | 1.450V |
| 10001 | Float | GND | GND | GND | Float | 1.425V |
| 10010 | Float | GND | GND | Float | GND | 1.400V |
| 10011 | Float | GND | GND | Float | Float | 1.375V |
| 10100 | Float | GND | Float | GND | GND | 1.350V |
| 10101 | Float | GND | Float | GND | Float | 1.325V |
| 10110 | Float | GND | Float | Float | GND | 1.300V |
| 10111 | Float | GND | Float | Float | Float | 1.275V |
| 11000 | Float | Float | GND | GND | GND | 1.250V |
| 11001 | Float | Float | GND | GND | Float | 1.225V |
| 11010 | Float | Float | GND | Float | GND | 1.200V |
| 11011 | Float | Float | GND | Float | Float | 1.175V |
| 11100 | Float | Float | Float | GND | GND | 1.150V |
| 11101 | Float | Float | Float | GND | Float | 1.125V |
| 11110 | Float | Float | Float | Float | GND | 1.100V |
| 11111 | Float | Float | Float | Float | Float | NO_CPU (1.075V) |

APPLICATIONS INFORMATION

Besides the LTC1629, the LTC1706-82 also programs a whole family of LTC DC/DC converters that have an onboard 0.8V reference. The LTC1628, LTC1735, LTC1702, LTC1772, LTC1929 and LTC3729 are just a few of the high efficiency step-down switching regulators that will work equally well with the LTC1706-82.

PACKAGE DESCRIPTION

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

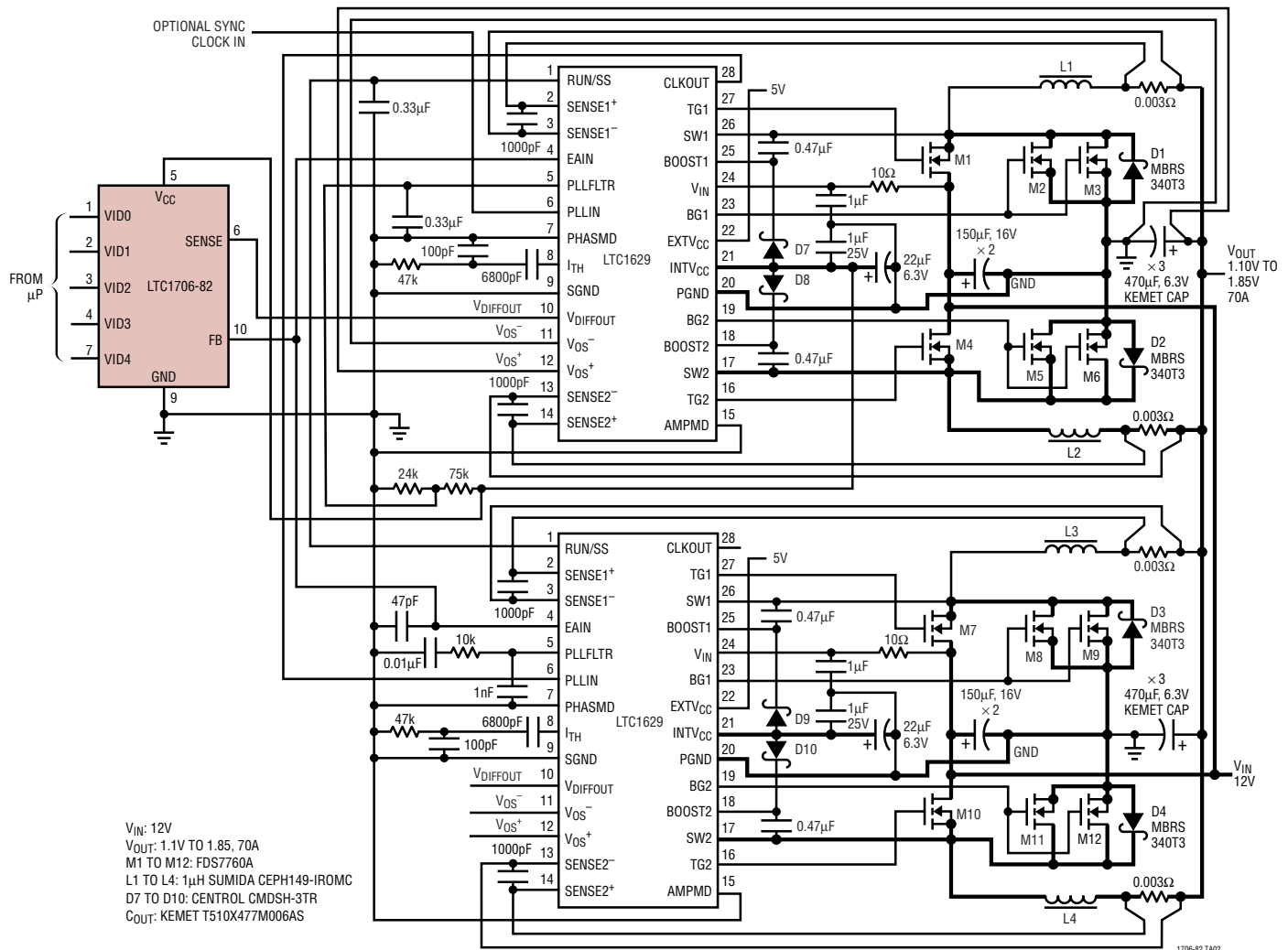


NOTE:

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

TYPICAL APPLICATION

VID Controlled High Current 70A 4-Phase Power Supply



RELATED PARTS

| PART NUMBER | DESCRIPTION | COMMENTS |
|--------------------|---|---|
| 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 [®] 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} [™] , $2.7V \leq V_{IN} \leq 7V$ |
| LTC1706-81 | 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 |
| 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 |
| LTC1929/LTC1929-PG | 2-Phase Sync Step-Down Controller | Current Mode Operation, I _{OUT} Up to 40A, $3.5V \leq V_{IN} \leq 36V$ |
| LTC3732 | 3-Phase, 5-Bit VID, Synchronous Step-Down Controller | I _{OUT} ≤ 60A, VRM9.0/9.1 Compatible, 600kHz per Phase Operation, Integrated MOSFET Drivers. |

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