LINEAR TECHNOLOGY

LTC1706-85

VID Voltage Programmer for Intel VRM 8.5

FEATURES

- **Fully Compliant with the Intel VRM 8.5 VID Specification**
- **Programs Regulator Output Voltage from 1.05V to 1.825V in 25mV Steps**
- **Programs an Entire Family of Linear Technology DC/DC Converters with 0.8V References**
- ±0.25% Voltage Programming Accuracy
- Built-In 40k Pull-Up Resistors on Program Inputs
- Available in MSOP-10 Packaging

APPLICATIONS

- Server/Desktop Computers
- Multiprocessor Workstations and Servers
- Multiphase Processor Power Supply

DESCRIPTION

The LTC®1706-85 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 1.05V and 1.825V is programmed in 25mV increments.

The LTC1706-85 is designed specifically to program an entire family of Linear Technology DC/DC converters in full compliance with the Intel Voltage Regulator Module (VRM) 8.5 specification.

The LTC1706-85 programs the following Linear Technology DC/DC converter products: LTC1622, LTC1628, LTC1629, LTC1702, LTC1735, LTC1735-1, LTC1772, LTC1773, LTC1778, LTC1929, LTC3728 and LTC3729.

Consult factory for additional DC/DC converter products compatible with the LTC1706-85.

TYPICAL APPLICATION

VID Controlled High Current 4-Phase DC/DC Converter (Simplified Block Diagram)
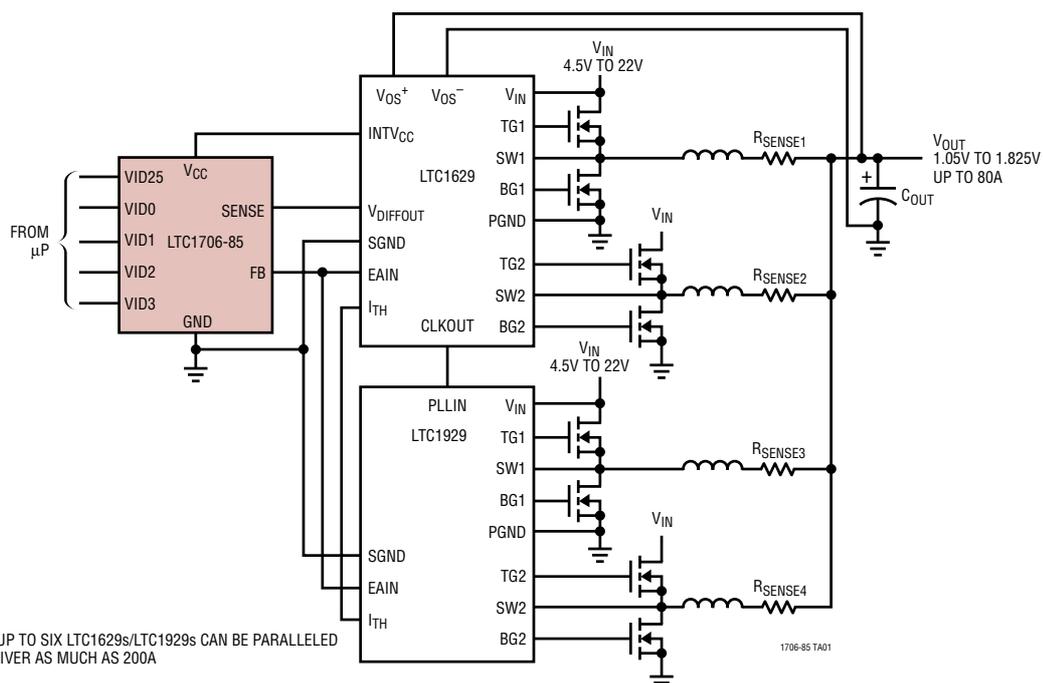
NOTE: UP TO SIX LTC1629s/LTC1929s CAN BE PARALLELED TO DELIVER AS MUCH AS 200A

1706-85 TA01

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ABSOLUTE MAXIMUM RATINGS

(Notes 1, 2)

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 3) .. −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

TOP VIEW

VID25 1 | 10 FB
VID0 2 | 9 GND
VID1 3 | 8 NC
VID2 4 | 7 VID3
V_{CC} 5 | 6 SENSE

MS PACKAGE
10-LEAD PLASTIC MSOP

$T_{JMAX} = 110°C$, $\theta_{JA} = 200°C/W$

ORDER PART NUMBER
LTC1706EMS-85

MS PART MARKING
LTYQ

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°C.
2.7V ≤ V_{CC} ≤ 5.5V, VID25 = VID0 = VID1 = VID2 = VID3 = NC unless otherwise noted. (Note 3)

SYMBOL	PARAMETER	CONDITIONS		MIN	TYP	MAX	UNITS
V_{CC}	Operating Supply Voltage Range			2.7		5.5	V
I_{VCC}	Supply Current	(Note 4)			1	10	µA
R_{FB1}	Resistance Between SENSE and FB		●	6	10	14	kΩ
$V_{OUT(ERROR)}$	Output Voltage Accuracy	$1.050 ≤ V_{SENSE} ≤ 1.825V$	●	−0.25		0.25	%
R_{PULLUP}	Pull-Up Resistance on VID	V_{DIODE} = 0.6V (Note 5)		28	40	56	kΩ
V_{IH}	Minimum High Level Input Voltage (VID Inputs)	V_{CC} = 3.3V		2			V
V_{IL}	Maximum Low Level Input Voltage (VID Inputs)	V_{CC} = 3.3V				0.8	V
I_{IN}	Input Leakage Current (VID Inputs)	V_{CC} < VID < 7V (Note 5)			0.01	±1	µA

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

Note 2: All voltages are with respect to GND pin.

Note 3: The LTC1706-85 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 4: Supply current is specified with all VID inputs floating. Due to the internal pull-ups on the VID pins, the supply current will increase

depending on the number of grounded VID lines. Each grounded VID line will draw approximately $[(V_{CC} – 0.6)/40]$mA. If the VID inputs are left unconnected, they will float to V_{CC} at a rate controlled by parasitic capacitance. Until the VID inputs reach their final states, slightly higher I_{VCC} current may be observed. (See the Operation section for more detail.)

Note 5: 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
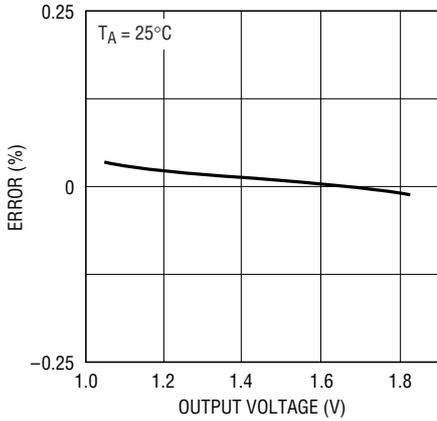
1706-85 G01

### Typical Error % vs Temperature
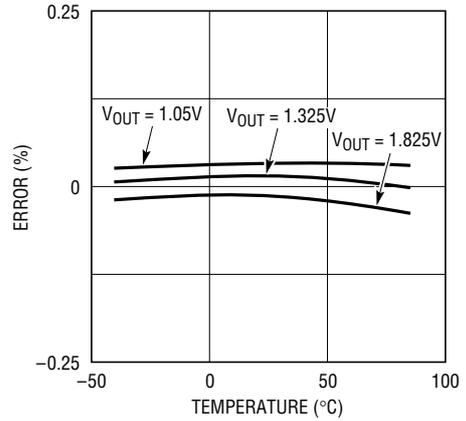
1706-85 G02

R_{FB1} vs Temperature
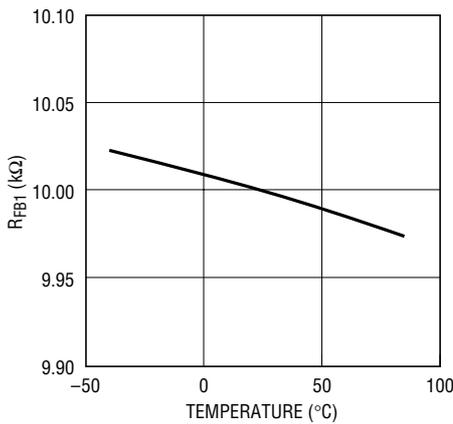
1706-85 G03

VID Pullup Current vs Temperature
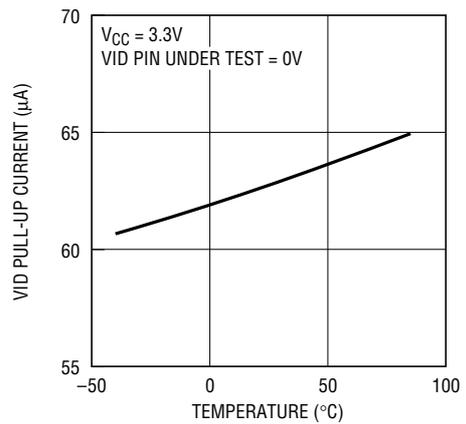
1706-85 G04

Supply Current vs Temperature
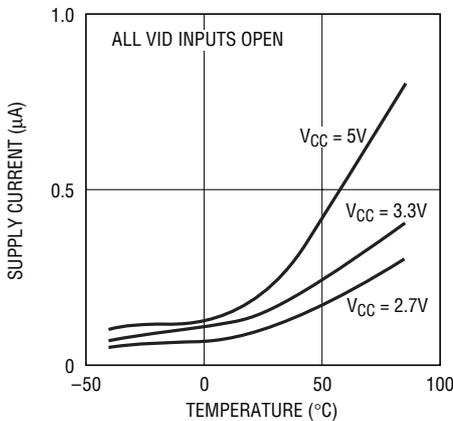
1706-85 G05

Supply Current vs Supply Voltage
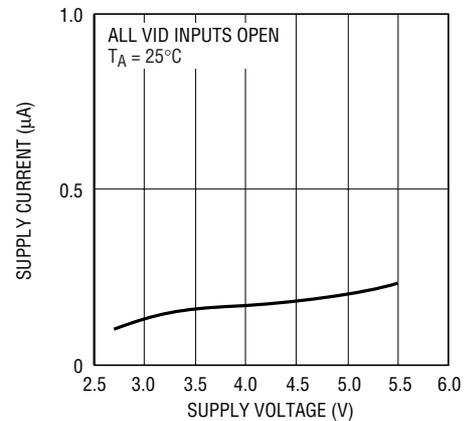
1706-85 G06

PIN FUNCTIONS

VID25 (Pin 1): Programming Input. GND = LOW, V_{CC} or Float = HIGH. Refer to Table 1 for programming information. Connect to associated VID pin of μP.

VID0 (Pin 2): Programming Input. GND = LOW, V_{CC} or Float = HIGH. Refer to Table 1 for programming information. Connect to associated VID pin of μP.

VID1 (Pin 3): Programming Input. GND = LOW, V_{CC} or Float = HIGH. Refer to Table 1 for programming information. Connect to associated VID pin of μP.

VID2 (Pin 4): Programming Input. GND = LOW, V_{CC} or Float = HIGH. Refer to Table 1 for programming information. Connect to associated VID pin of μP.

V_{CC} (Pin 5): Power Supply Voltage. May 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 LTC1929 or LTC1629.

**VID3 (Pin 7):** Programming Input. GND = LOW, V_{CC} or Float = HIGH. Refer to Table 1 for programming information. Connect to associated VID pin of μP.

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 LTC1929 or LTC1629.

BLOCK DIAGRAM
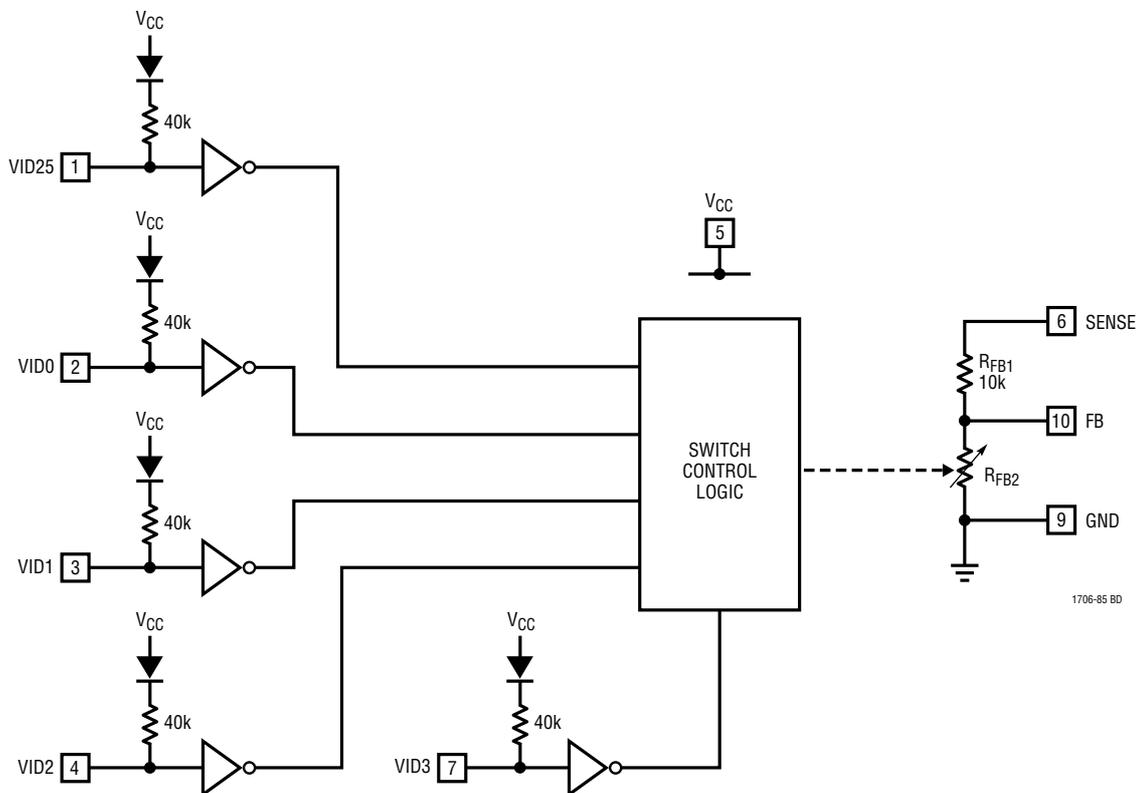
1706-85 BD

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OPERATION

The LTC1706-85 is a precision programmable 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 LTC1706-85 programs an output voltage ranging from 1.050V to 1.825V in 25mV steps, depending on the state of the VID input pins. The LTC1706-85 in conjunction with a Linear Technology DC/DC switching regulator can be used to create a high performance voltage regulator meeting all the requirements of the Intel VRM 8.5 specification.

Voltage Sensing and Feedback Pins

The LTC1706-85 operates by closing the loop between the output node and the feedback node of the regulator with an appropriate resistive divider network. The "top" feedback resistor, R_{FB1}, connected between SENSE and FB, is a fixed value of typically 10k. The "bottom" feedback resistor, R_{FB2}, is set by the five VID inputs to generate the desired regulator output voltage. Feedback resistors R_{FB1} and R_{FB2} are matched and temperature stable in order to provide a highly accurate output voltage.

The FB pin is a sensitive node in the circuit. Care should be taken to minimize the layout distance between the LTC1706-85 FB node and the regulator feedback node. In addition, it is important to keep tight ground connections between the two chips.

VID Inputs

The desired output voltage is obtained by applying the proper voltage or float condition to the five digital VID inputs. Table 1 shows the translation table with each input state and the corresponding regulator output voltage. This translation is derived from and adheres to the Intel VRM 8.5 specification.

Each VID input is pulled up by a 40k resistor in series with a diode connected to V_{CC}. To produce a digital low a VID input should be grounded or driven to a low state. The VID inputs must be driven with a maximum V_{IL} of 0.8V (V_{CC} = 3.3V).

When a VID input is grounded or pulled low with a logic gate, the power supply current will increase because of the resistor from V_{CC} through the series diode to the input. This increase in current is calculated from:

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

where N is the number of grounded VID inputs. With typical values of V_{CC} = 3.3V, V_{DIODE} = 0.6V and R_{PULLUP} = 40k, each grounded V_{IN} input will sink approximately 68µA.

To apply a digital high state the input can be either floated, connected to V_{CC} or driven by a logic gate. The VID inputs should be driven with a minimum V_{IH} of 2V (V_{CC} = 3.3V). Because of the diode between V_{CC} and the pull-up resistor, the maximum V_{IH} is not limited to V_{CC}. The VID inputs can be driven higher than V_{CC} without being clamped or damaged. This allows the LTC1706-85 to be fully logic compatible and operational over a wide input voltage range, up to the 7V absolute maximum rating.

When used with the LTC1629 and LTC1929, the LTC1706-85's FB, SENSE, V_{CC} and GND pins should be connected respectively to 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 applicable to any low output voltage system such as a personal computer, workstation or network server.

In addition to the LTC1629 and LTC1929, the LTC1706-85 also programs a whole family of LTC DC/DC converters that have an onboard 0.8V reference. The LTC1628, LTC1735 and LTC1622 are just a few of the high efficiency step-down switching regulators that will work equally well with the LTC1706-85. Contact LTC Marketing for a more complete listing of compatible DC/DC regulators.

OPERATION

Table 1. VID Inputs and Corresponding Output Voltage

CODE	VID3	VID2	VID1	VID0	VID25	VOLTAGE	CODE	VID3	VID2	VID1	VID0	VID25	VOLTAGE
00000	GND	GND	GND	GND	GND	1.250	10000	Float	GND	GND	GND	GND	1.650
00001	GND	GND	GND	GND	Float	1.275	10001	Float	GND	GND	GND	Float	1.675
00010	GND	GND	GND	Float	GND	1.200	10010	Float	GND	GND	Float	GND	1.600
00011	GND	GND	GND	Float	Float	1.225	10011	Float	GND	GND	Float	Float	1.625
00100	GND	GND	Float	GND	GND	1.150	10100	Float	GND	Float	GND	GND	1.550
00101	GND	GND	Float	GND	Float	1.175	10101	Float	GND	Float	GND	Float	1.575
00110	GND	GND	Float	Float	GND	1.100	10110	Float	GND	Float	Float	GND	1.500
00111	GND	GND	Float	Float	Float	1.125	10111	Float	GND	Float	Float	Float	1.525
01000	GND	Float	GND	GND	GND	1.050	11000	Float	Float	GND	GND	GND	1.450
01001	GND	Float	GND	GND	Float	1.075	11001	Float	Float	GND	GND	Float	1.475
01010	GND	Float	GND	Float	GND	1.800	11010	Float	Float	GND	Float	GND	1.400
01011	GND	Float	GND	Float	Float	1.825	11011	Float	Float	GND	Float	Float	1.425
01100	GND	Float	Float	GND	GND	1.750	11100	Float	Float	Float	GND	GND	1.350
01101	GND	Float	Float	GND	Float	1.775	11101	Float	Float	Float	GND	Float	1.375
01110	GND	Float	Float	Float	GND	1.700	11110	Float	Float	Float	Float	GND	1.300
01111	GND	Float	Float	Float	Float	1.725	11111	Float	Float	Float	Float	Float	1.325

TYPICAL APPLICATIONS

30A, 2-Phase VID Controlled Power Supply

V_{IN}: 12V
V_{OUT}: 1.05V TO 1.825, 30A
M1 TO M6: FDS7760A
L1 TO L2: 1µH SUMIDA CEP125-IROMC-H
D7 TO D10: CENTRAL CMDSH-3TR
C_{OUT}: PANASONIC EEFUEOG181R

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TYPICAL APPLICATIONS

VID Controlled High Current 70A 4-Phase Power Supply

V$_{IN}$: 12V
V$_{OUT}$: 1.05V TO 1.825, 70A
M1 TO M12: Si7440DP
L1 TO L4: 1μH SUMIDA CEP125-IROMC-H
D7 TO D10: CENTRAL CMDSH-3TR
C$_{OUT}$: KEMET T510X477M006AS

1706-85 TA03
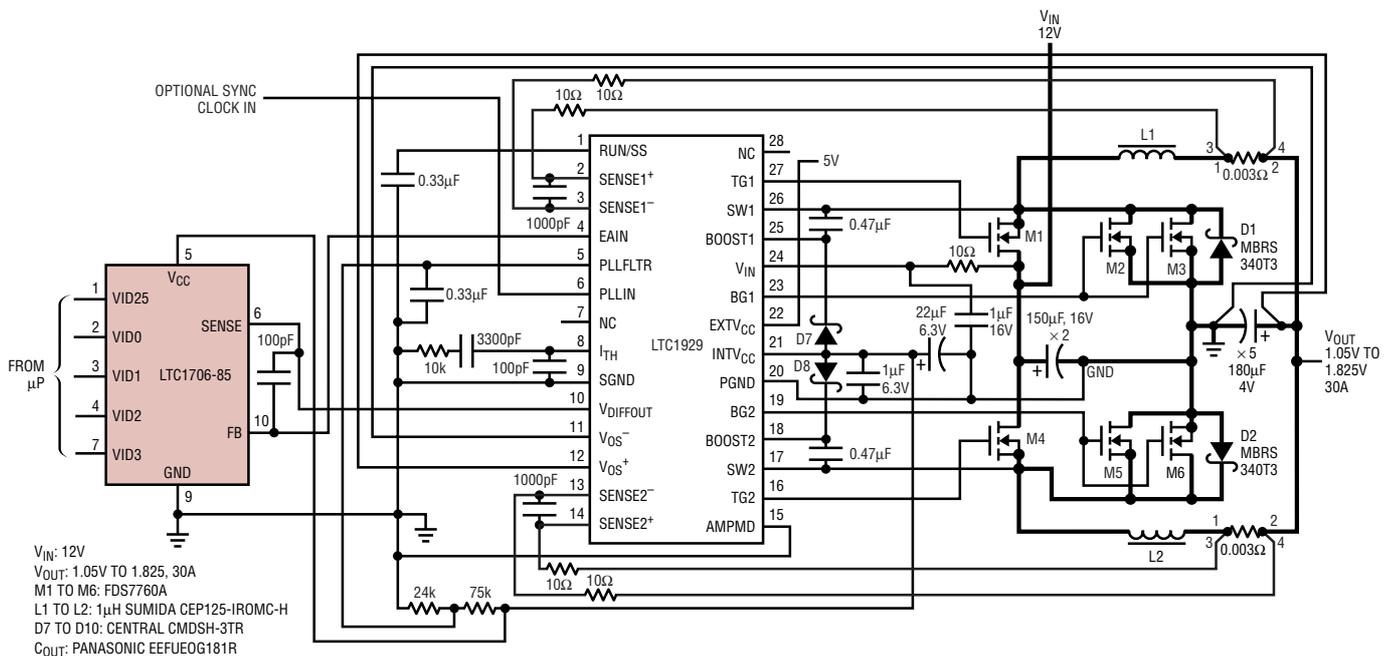
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PACKAGE DESCRIPTION

MS Package
10-Lead Plastic MSOP
(Reference LTC DWG # 05-08-1661)
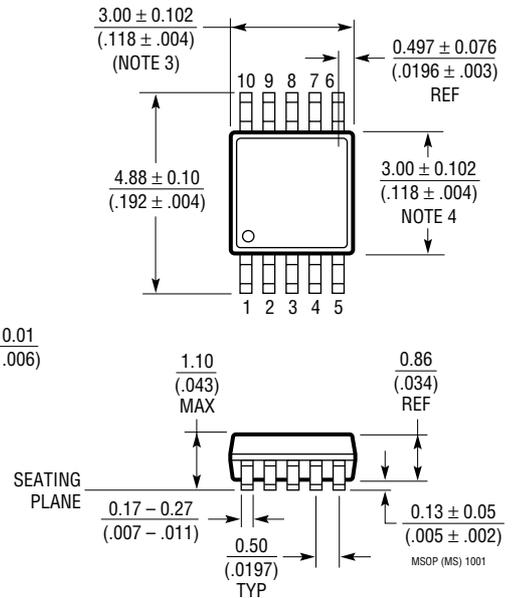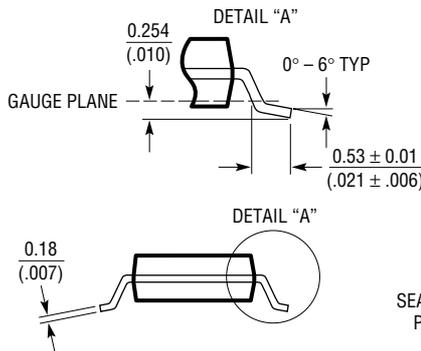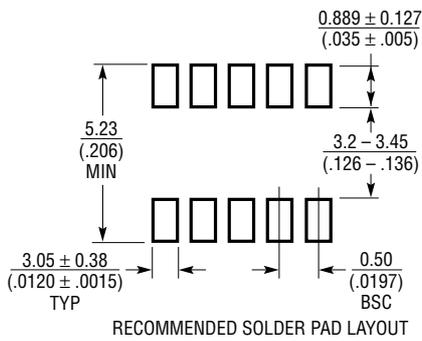
NOTE:
1. DIMENSIONS IN MILLIMETER/(INCH)
2. DRAWING NOT TO SCALE
3. DIMENSION DOES NOT INCLUDE MOLD FLASH, PROTRUSIONS OR GATE BURRS.
   MOLD FLASH, PROTRUSIONS OR GATE BURRS SHALL NOT EXCEED 0.152mm (.006") PER SIDE
4. DIMENSION DOES NOT INCLUDE INTERLEAD FLASH OR PROTRUSIONS.
   INTERLEAD FLASH OR PROTRUSIONS SHALL NOT EXCEED 0.152mm (.006") PER SIDE
5. LEAD COPLANARITY (BOTTOM OF LEADS AFTER FORMING) SHALL BE 0.102mm (.004") MAX

RELATED PARTS

PART NUMBER	DESCRIPTION	COMMENTS
LTC1622	Sychnronizable Low Voltage Step-Down Controller	8-Pin MSOP, 2V ≤ V_{IN} ≤ 10V, 550kHz, Burst Mode® Operation
LTC1628/LTC1628-PG	Dual High Efficiency, 2-Phase Sync Step-Down Controller	Constant Freq, Standby, 5V and 3.3V LDOs, 3.5V ≤ V_{IN} ≤ 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 ≤ V_{IN} ≤ 7V
LTC1706-81/LTC1706-82	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 ≤ V_{IN} ≤ 36V, PLL, 36-Pin SSOP, Current Mode Operation
LT1709-85	2-Phase, 5-Bit VID, Current Mode High Efficiency Synchronous Step-Down Switching Regulator	4V ≤ V_{IN} ≤ 36V, 36-Pin SSOP VRM 8.5 Compatiable
LTC1735	High Efficiency Sync Step-Down Controller	Burst Mode Operation, 16-Pin Narrow SSOP, Fault Protection, 3.5V ≤ V_{IN} ≤ 36V
LTC1736	High Efficiency Sync Buck Controller with 5-Bit Mobile VID	GN-24, Power Good, Output Fault Protection, 3.5V ≤ V_{IN} ≤ 36V
LTC1772	SOT-23 Low Voltage Step-Down Controller	6-Pin SOT-23, 2.5V ≤ V_{IN} ≤ 10V, 550kHz, Burst Mode Operation
LTC1773	Synchronous Step-Down DC/DC Controller	Up to 95% Efficiency, 550kHz Operation, 2.65V ≤ V_{IN} ≤ 8.5V, 0.8 ≤ V_{OUT} ≤ V_{IN}
LTC1778	Wide Operating Range Step-Down Controller	No R_{SENSE}, V_{IN} up to 36V, Current Mode Power Good
LTC1929/LTC1929-PG	2-Phase Sync Step-Down Controller	Current Mode Operation, I_{OUT} Up to 40A, 3.5V ≤ V_{IN} ≤ 36V
LTC3728	550kHz, 2-Phase Dual Output Synchronous Step-Down Controller	Synchronizable, Current Mode, 3.5V ≤ V_{IN} ≤ 36V, I_{OUT} up to 25A
LTC3729	550kHz, PolyPhase, High Efficiency Synchronous Step-Down Switching Regulator	Current Mode, 4V ≤ V_{IN} ≤ 36V, 28-Lead SSOP package

Burst Mode and PolyPhase are registered trademarks of Linear Technology Corporation.
No R_{SENSE} is a trademark of Linear Technology Corporation.

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