![LINEAR TECHNOLOGY]

LTC4099EPDC: High Efficiency I²C Controlled USB Power Manager/Charger with Overvoltage Protection

DESCRIPTION

Demonstration Circuit 1396A is a high efficiency USB Power/Li-Ion battery manager plus a HV regulator battery tracking controller. The LTC4099EPDC is available in a 20-pin (3mm × 4mm × 0.55mm) UTQFN surface mount package.

LT, LTC, LTM, LT, Burst Mode, OPTI-LOOP, Over-The-Top and PolyPhase are registered trademarks of Linear Technology Corporation. Adaptive Power, C-Load, DirectSense, Easy Drive, FilterCAD, Hot Swap, LinearView, µModule, Micropower SwitcherCAD, Multimode Dimming, No Latency $\Delta\Sigma$, No Latency Delta-Sigma, No R_{SENSE}, Operational Filter, PanelProtect, PowerPath, PowerSOT, SmartStart, SoftSpan, Stage Shedding, SwitcherCAD, ThinSOT, UltraFast and VLDO are trademarks of Linear Technology Corporation. Other product names may be trademarks of the companies that manufacture the products.

PERFORMANCE SUMMARY Specifications are at T_A = 25°C

SYMBOL	PARAMETER	CONDITIONS	MIN	TYP	MAX	UNITS
VUSB	VUSB Input Voltage Range	Input disabled from 6V–30V	4.35		5.5	V
VOUT	VOUT Output Voltage Range	Range is mode and load dependant	3.5		5.5	V
V_{BAT}	Output Float Voltage	Constant voltage mode		4.2		V
I_{BAT}	Output Charge Current	Constant current mode		0.5	1	A

SOFTWARE GUI

The DC1396A Demo Circuit can be controlled from a software GUI. This software GUI is necessary to control many functions of the LTC4099. In addition, a DC590 board is necessary to connect the DC1396A to the PC. For proper testing of the Production Dem O Circuits, the Beta version or the released version of the QuickEval installation program should be used to load the DC1396 GUI. This is a screen shot of the GUI:

Figure 1: LTC4099 GUI screenshot

The GUI, along with R8 and R9, allows complete configuration of the functionality of the LTC4099. The input current limit, charge current, float voltage, C/x threshold, thermal regulation temperature, and safety timer period can be programmed. The battery charger and battery conditioner can be turned on and off.

The internal status word can be read back, and the conditions which cause an interrupt can be set.

The GUI will remember most functions from session to session, and can be set to defaults with a single button push.
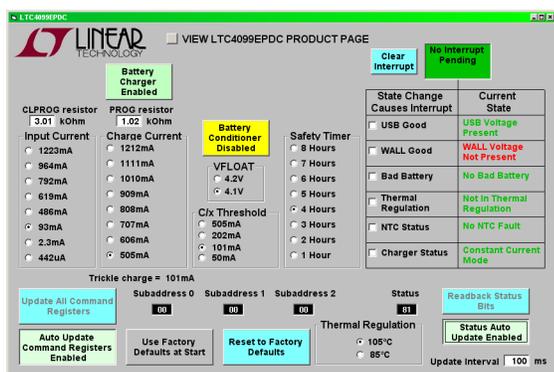
Input Current Limit

The input current limit can be set to one of eight levels, determined by the CLPROG (R9) resistor. The value of the eight levels is computed dynamically if the resistor value is edited. The resistor value is remembered, if the save values button is active. The value of the CLPROG resistor in in kΩ.

Charge current

The battery charge current can be set to one of eight levels determined by the PROG (R8) resistor. The of

![LINEAR TECHNOLOGY]

the eight levels is computed dynamically if the resistor value is edited. The resistor value is remembered, if the save values button is active. The value of the PROG resistor is in kΩ.

Interrupt generation
The conditions that cause an interrupt can be controlled. Please note that interrupts are generated on any change in the enabled conditions.
For example, if "USB Good" is enabled, then an interrupt will be generated for both USB voltage becoming valid and for USB voltage becoming invalid.

Status readback
The status readback can be set to readback automatically at the interval in the "Update Interval" input box. This defaults to 100ms.

Register display
The command registers values sent over the I2C are displayed, as well as the currently readback status values. This is a programming aid.

QUICK START PROCEDURE

Using short twisted pair leads for any power connections, with all loads and power supplies off, refer to Figures 2 & 3 for the proper measurement and equipment setup.

A companion HV Buck demo board is required for this check out procedure. The DC1394 (LT3480) board is recommended, and will be used for the following procedure. Please refer to the DC1394 Quick Start Guide for further information.

Please note that the following procedure assumes that the default values of the GUI, R8, and R9.

Follow the procedure below:

1. Set PS1 to 5V, and PS4 to 3.6V. Start LTC4099 GUI. Observe VOUT (VM5), I (VUSB) (AM1), V(CLPROG) (VM4) and V(PROG) (VM7). The LTC4099 defaults to 100mA input current limit and 500mA battery charger current. Since the battery current exceeds the current available from the USB port, VOUT collapses to nearly the battery voltage of 3.6V.

2. Use the GUI to set the input current limit to 1000mA. Observe VOUT (VM5), I (VUSB) (AM1), V(CLPROG) (VM4) and V(PROG) (VM7). The input current limit is now greater that the battery charge current, so VOUT rises to V(BAT) + 0.3V, or 3.9V.

3. Use the GUI to set the input current limit o 1260mA. Set Ld1 to 1A. Observe VOUT (VM5), I(VUSB) (AM1), V(CLPROG) (VM4) and V(PROG) (VM7). The input current limit is sufficient to supply 1.5 amps, Ld1 current plus battery charger current of 0.5A, and VOUT is 3.9V. 1260mA input current limit is sufficient due to the transformer action of the VOUT regulator, which exchanges output voltage for output current.

4. Set Ld1 to 0, and use the GUI to set charge current to 900mA. Observe VOUT(VM5), I(VUSB) (AM1), V(CLPROG) (VM4) and V(PROG) (VM7).

5. Set DC1395 "WALL" jumper (JP3) to "HVBUCK", "COMP" jumper (JP2) to "EXT", and "SYNC" jumper (JP1) to "PWM/SYNC". Turn on PS2 and set to 8V. Observe VOUT (VM5), I(VUSB) (AM1) and V(PROG) (VM7). The HV Buck regulator on the LT3480 board is now powering VOUT. Availability of this voltage is detected on the WALL pin, and this shuts down the VOUT buck regulator on the LTC4099, while enabling the VC pin to control the output voltage on VOUT. This preserves the Bat-Track feature, even when using an external HV Buck regulator.

6. Turn on PS2 and set to 32V. Observe VOUT (VM5), I(VUSB) (AM1) and V(PROG) (VM7).

7. Use to automatic readback of status, and to assert an interrupt on change of "WALL" input status. Turn off PS2. Did /IRQ LED light? Does GUI show interrupt? Clear interrupt in GUI. The interrupt generator has been set to generate an interrupt on any change on the validity of the voltage present on the WALL pin.

8. Move "NTC" jumper (JP1) to EXT. Did GUI show "Battery too cold"? Did /IRQ LED light? The status byte is reporting that the NTC temperature measurement indicated that battery was too cold. However, no interrupt was generated because the NTC interrupt wasn't enabled.

9. Set PS1 to 0V, and Ld1 to 0A. Observe VOUT (VM5) and V (VOUT, BAT) (VM5 – VM6). The Ideal Diode is on and powers VOUT from V (BAT).

10. Set Ld1 to 1A. Observe VOUT (VM5) and V (VOUT, BAT) (VM5-VM6). Set Ld1 to 0A.

11. Increase PS4, until GUI status indicates charger is in constant voltage mode. Observe V (BAT) (VM6).

12. Decrease PS4, until GUI indicates charger is in constant current mode. Observe V (BAT) (VM6).

13. Use GUI to set float voltage to 4.2V. Increase PS4, until GUI status indicates charger in constant voltage mode. Observe V (BAT) (VM6).

14. Decrease PS4, until GUI indicates charger is in constant current mode. Observe V (BAT) (VM6).

15. Set PS3 to 5V, set WALL (DC1394, JP3) to "5V ADAPTOR" and PS3 to 5V. Observe VOUT (VM6) and V (PROG) (VM5).
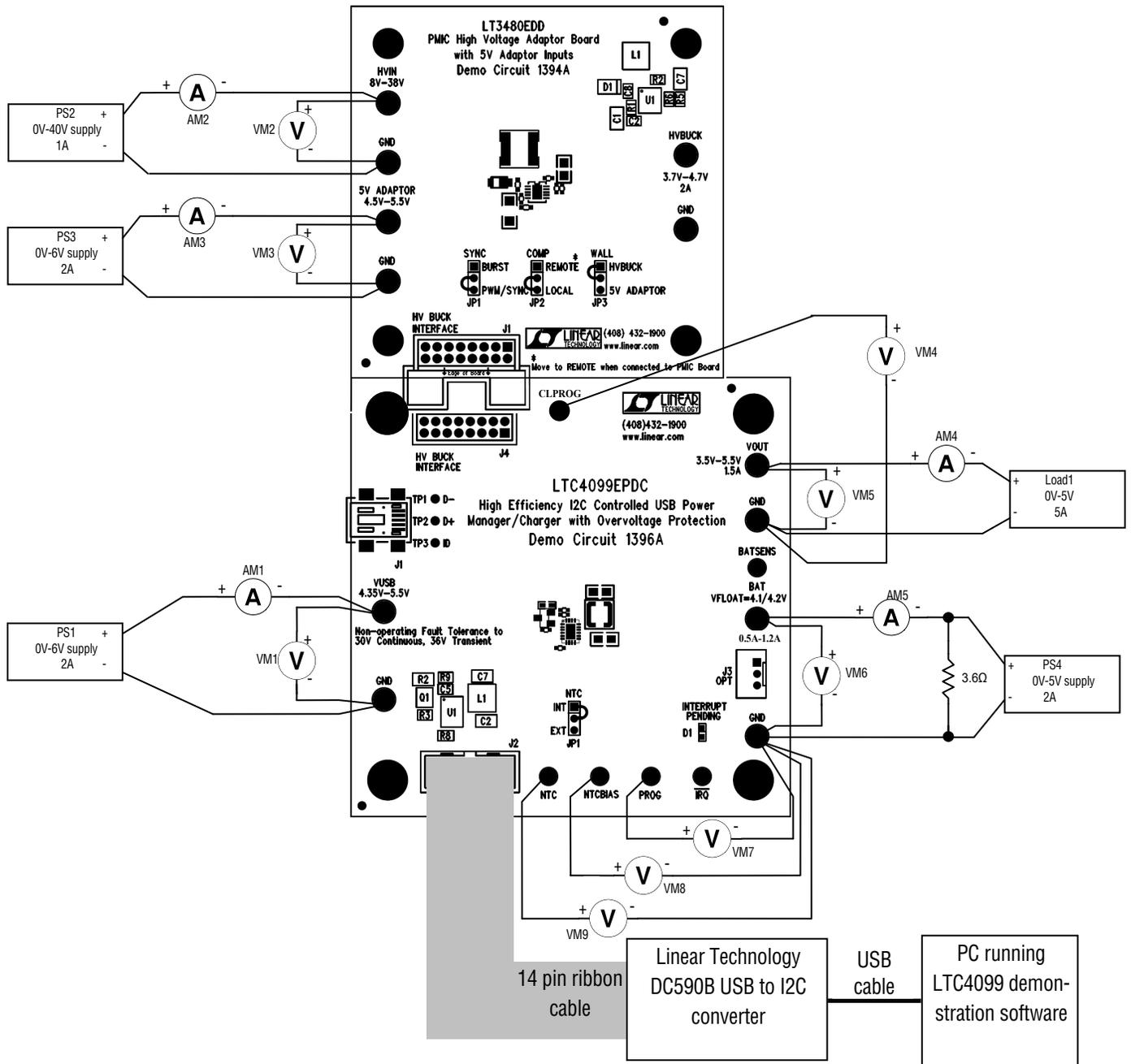
Note: All connections from equipment should be Kelvin connected directly to the Board PINS which they are connected to on this diagram and any input, or output, leads should be twisted pair

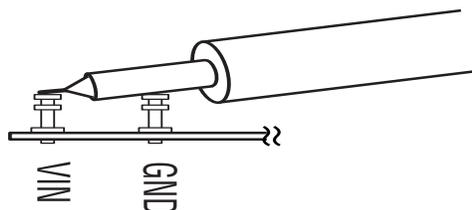**Figure 2. Proper Measurement Equipment Setup for DC1396A**

Figure 3. Measuring Input or Output Ripple

Figure 4. DC1396A Schematic

	Qty	Reference	Part Description	Manufacture / Part #
		REQUIRED CIRCUIT COMPONENTS:		
1	2	C2,C7	CAP, CHIP, X5R, 22µF, ±20%, 6.3V, 0805	TAIYO-YUDEN, JMK212BJ226MG
2	1	C5	CAP, CHIP, X7R, 0.1µF, ±10%, 16V, 0402	MURATA, GRM155R71C104KA88
3	1	L1	IND, SMT, 3.3µH, 2.2A, ±20%	COILCRAFT, LPS4018-332MLC
4	1	Q1	MOSFET, 30V, 50mΩ, 2.6A, SuperSOT-3	FAIRCHILD, FDN-372S
5	1	R2	RES, CHIP, 6.2kΩ, ±5%, 1/10W, 0603	VISHAY, CRCW06036K20JNED
6	1	R8	RES, CHIP, 1.02kΩ, ±1%, 1/16W, 0402	VISHAY, CRCW04021K02FKED
7	1	R9	RES, CHIP, 3.01kΩ, ±1%, 1/16W, 0402	VISHAY, CRCW04023K01FKED
8	1	U1	IC, SMT,High Efficiency I2C Controlled USB Power Manager/Charger with Over Voltage Protection	LINEAR TECH., LTC4099EPDC
		ADDITIONAL DEMO BOARD CIRCUIT COMPONENTS:		
1	1	C1	CAP, CHIP, X5R, 4.7µF, ±10%, 50V, 1206	MURATA, GRM31CR71H475KA12L
2	1	C3	CAP, CHIP, X7R, 0.1µF, ±10%, 16V, 0402	MURATA, GRM155R71C104KA88
3	1	C4	CAP, CHIP, X7R, 0.01µF, ±10%, 25V, 0402	VISHAY, VJ0402Y103KXXA
4	1	C6	CAP, CHIP, X5R, 100µF, ±20%, 6.3V, 1206	MURATA, GRM31CR60J107ME39L
5	1	D1	DIODE, LED, RED, 0603	PANASONIC, LNJ236W82RA
6	1	Q2	MOSFET, -12V, 35mΩ, -5.3A, SOT-23	VISHAY, Si2333DS
7	4	R1,R13,R14,R15	RES, CHIP, 1.0Ω, ±5%, 1/16W, 0402	VISHAY, CRCW04021R00JNED
8	3	R3,R10,R18	RES, CHIP, 100kΩ, ±1%, 1/16W, 0402	VISHAY, CRCW0402100KFKED
9	2	R4,R5	RES, CHIP, 5.1kΩ, ±5%, 1/16W, 0402	VISHAY, CRCW04025K10JNED
10	4	R6,R11,R12,R16	RES, CHIP, 0Ω jumper, 1/16W, 0402	VISHAY, CRCW04020000Z0ED
11	1	R7	RES, CHIP, 51kΩ, ±5%, 1/16W, 0402	VISHAY, CRCW040251K0JNED
12	1	R17	RES, CHIP, 1kΩ, ±5%, 1/10W, 0603	VISHAY, CRCW06031K00JNED
13	1	U2	I2C EEPROM	MICROCHIP, 24LC025-I/ST
		HARDWARE FOR DEMO BOARD ONLY:		
1	6	E1,E2,E7,E8,E11,E12	Turret, 0.09"	MILL-MAX, 2501-2
2	6	E3,E4,E5,E6,E9,E10	Turret, 0.061"	MILL-MAX, 2308-2
3	1	J1	CONN, USB MINI-B	TYCO,1734035-2
4	1	J2	CONN, I2C header	MOLEX, 87831-1420
5	0	J3-OPT	CONN, Battery	HIROSE, DF3-3P-2DSA
6	1	J4	CONN, HV interface	SAMTEC, SQT-108-01-F-D-RA
7	1	JP1	3 Pin Jumper, 2mm	SAMTEC, TMM-103-02-L-S
8	1	JP1	SHUNT 2mm	SAMTEC, 2SN-BK-G
9	4		STAND-OFF, NYLON 0.375" tall (SNAP ON)	KEYSTONE, 8832 (SNAP ON)

Figure 5. DC1396A BOM