# QUICK START GUIDE FOR DC1334A

# LTC3576EUFE
## Switching Power Manager + USB On-the-Go + OVP + HV Buck VC Control + 3 Bucks

## DESCRIPTION

Demonstration Circuit DC1334A is a Switching Power Manager with USB On-the-Go + Triple Step Down DC/DCs. The LTC3576EUFE is available in a 38-pin (4mm × 6mm) QFN surface mount package.

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## 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 | | 30 | 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 DC1334A Demo Circuit can be controlled from a software GUI. Most of the features of the LTC3576EUFE are only accessible via the I2C channel. When the QuikEval program is active and a DC590 with a DC1334A connected and attached to the USB cable, the "LTC3576" form should automatically pop up and be fully operational:

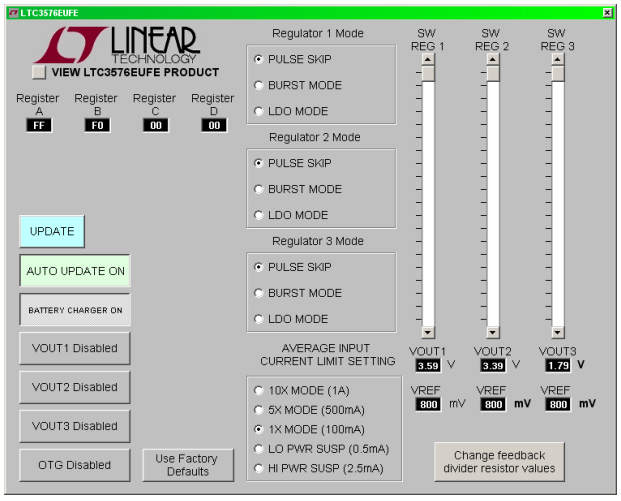



**Figure 1. GUI control panel**

SOFTWARE OPERATION

The software GUI automatically opens the control panel shown above. This control panel allows control of most major functions of the LTC3576. The EN1, EN2, EN3, and ENOTG signals are wire OR'ed with individual regulator enable regulator signals from the I2C channel. Consequent to this, if the ENx or ENOTG signals are high, the regulators will be enabled regardless of the state of the I2C channel regulator control bits.

Register A , B, C and D display

These are not writeable and are provided as a programming aid. The current value of the I2C A ,B, C and D registers are displayed.

Update button

Forces an immediate update of the I2C registers.

Autoupdate button

If enabled (default) will update the I2C channel whenever something is changed.

Battery charger button
If on (default) the battery charger in the LTC3576 will be enabled, and if off the battery charger will be disabled.

VOUT1~VOUT3 buttons
Individually enable or disable the three voltage regulators. These only function if the ENx pins are held low.

Switchmode Regulators mode
Set the mode of operation of all the switchmode regulators.

VOUT1, VOUT2 and VOUT3 sliders
Allow control of voltage regulator 1, 2 and 3 output voltages by adjusting the respective reference DACs.

VOUT1~3 output and reference voltages
These are not writeable, but reflect the current state of the reference DACs, and feedback resistors.

Input current limit
Set the maximum power drawn from the USB port.

Change feedback divider resistor values
This opens the form:

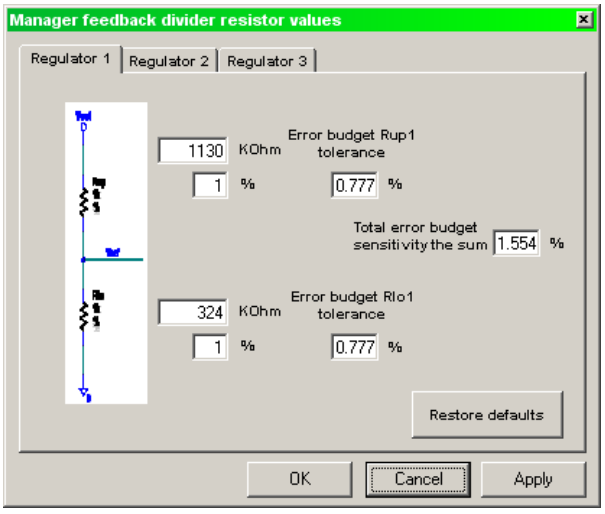



**Figure 2. Feedback resistor control panel**

This form allows the feedback resistor divider network on each regulator to be changed. The information changed here, is saved, and is durable from session to session. However, the factory values can be recovered by pressing the "Restore defaults" button

## QUICK START PROCEDURE

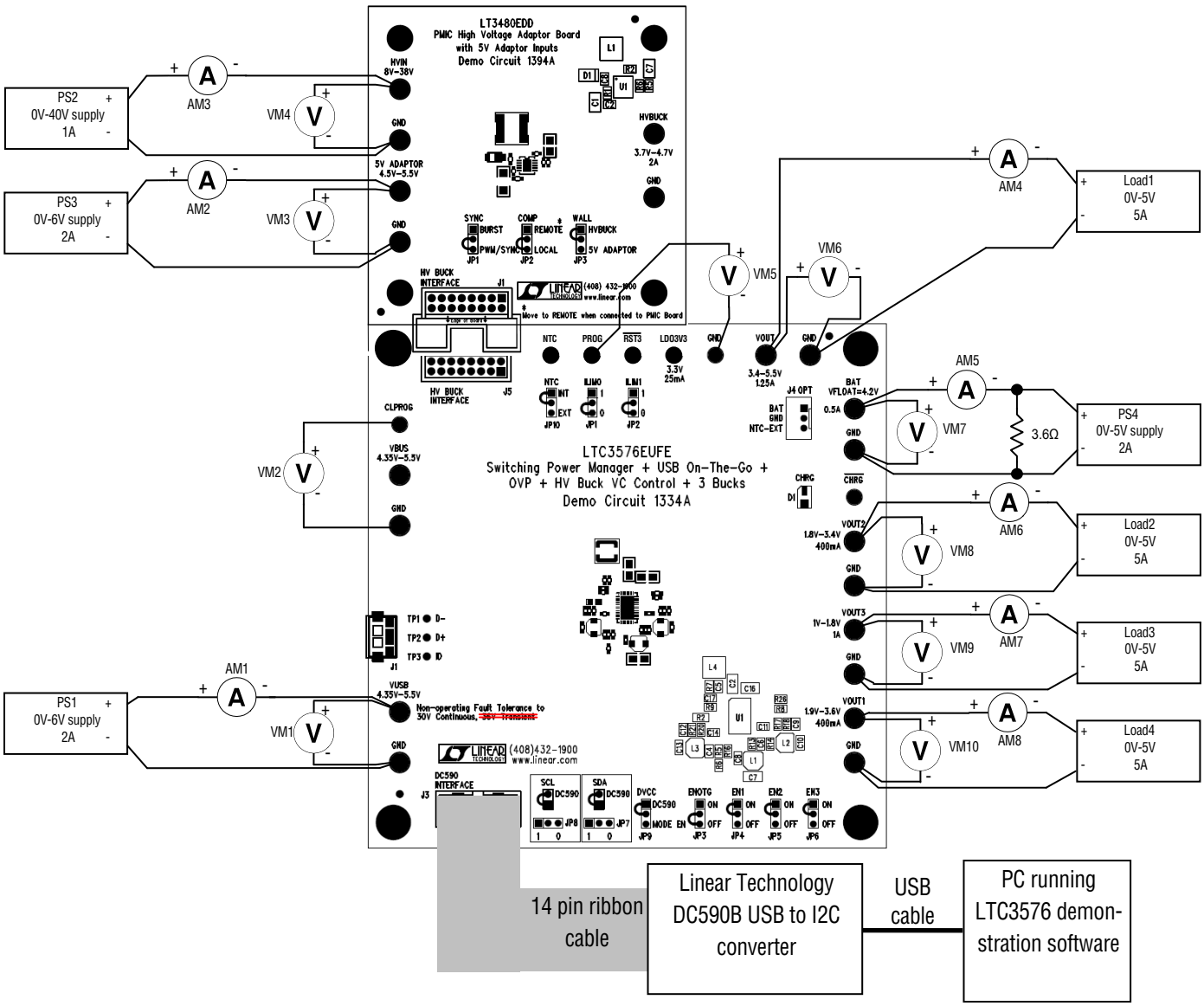
Using short twisted pair leads for any power connections, with all loads and power supplies off, refer to Figures 2 & 3 for the proper measurement and equipment setup.

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.

Follow the procedure below:

1. Set "DVCC" jumper (JP9) to "MODE", JP7 & JP8 to "0". Do not start the GUI, at this time, as JP9 has disabled the $I^2C$ interface.
2. Set PS1 to 5V, and PS4 to 3.6V. Observe that 3.55V < VOUT (VM6) < 3.70V and 80mA < I (VUSB) (AM1) < 95mA. The USB current limit is set for 1X (100mA), and the battery charger is set to 500mA. So, VOUT collapses until the charge current matches the current available from the USB input.
3. Set ILIM1 (JP2) and ILIM0 (JP1) to "1". Observe that 3.80 < VOUT (VM4) < 4.10V and 380mA < I(VUSB) < 420mA (AM1). The USB input current limit is now 5X (500mA), and the VOUT switching regulator behaves like a transformer, exchanging output current for output voltage. So, the input current is ≈ (VOUT/VUSB) * 500mA. Set Load 1 to 0A.
4. Set ILIM1 (JP2) to "0" and ILIM0 (JP1) to "1". Set Load 1 to 500mA. Observe 4.00V < VOUT < 4.15V (VM4) and 760mA < I(VUSB) < 840mA (AM1). The USB input current limit is now 10X (1A).
5. Set "DVCC" Jumper (JP9) to "DVCC", JP7 and JP8 to "DC590". Start the GUI
6. Set PS1 to 5V, and PS4 to 3.6V. . Observe that 3.55V < VOUT (VM6) < 3.70V and 80mA < I (VUSB) (AM1) < 95mA. The USB current limit is set for 1X (100mA), and the battery charger is set to 500mA. So, VOUT collapses until the charge current matches the current available from the USB input.
7. Use GUI to set "Average input current limit setting" to "5X Mode (500mA). . Observe that 3.55V < VOUT (VM6) < 3.70V and 80mA < I(VUSB) (AM1) < 95mA. The USB current limit is set for 1X (100mA), and the battery charger is set to 500mA. So, VOUT collapses until the charge current matches the current available from the USB input.
8. Use GUI to set "Average input current limit setting" to "10X Mode (1A). Set Load 1 to 500mA. Observe 4.00V < VOUT < 4.15V (VM4) and 760mA < I (VUSB) < 840mA (AM1). The USB input current limit is now 10X (1A).
9. Set PS1 to 0V, and Load 1 to 0A. Observe that 3.50V < VOUT 3.65V (VM6) and V (VOUT, BAT) < 30mV (VM6 - VM7). The ideal diode is now on, with a minimal load on VOUT.
10. Set Load 1 to 1A. Observe that 3.50V < VOUT (VM6) < 3.60V and V(VOUT,BAT) < 0.10V (VM6 – VM7). Set Load 1 to 0A. The ideal diode is on and supplying the 1A Load 1 load from the battery.
11. Set NTC (JP4) to "EXT". Does the "Battery Charging" LED blink? Set NTC (JP4) to "INT".
12. Set WALL (DC1394, JP3) to "HVBUCK", COMP (DC1394, JP2) to "REMOTE", and SYNC (DC1394, JP1) to "RUN/SYNC". Increase PS2 from 0V to 8V. Observe that 3.80 V < VOUT < 4.10V (VM6) and 0.98V < V(PROG) < 1.02V (VM5). The HV Buck regulator is now providing power to VOUT, and the internal regulator has stopped supplying power from the USB port.
13. Set Load 1 to 1A. Observe that 3.80V < VOUT < 4.10V (VM6) and 0.98V < V (PROG) < 1.02V (VM5).

14. Set PS2 to 38V. Measure VOUT (VM6) and V (PROG) (VM5). Observe that 3.80V < VOUT < 4.10V (VM6) and 0.98V < V (PROG) < 1.02V (VM5).
15. Set WALL (DC1394, JP3) to “5V ADAPTOR” and PS3 to 5V. Observe that 4.40V < VOUT 5.40V (VM6) and 0.98V < V (PROG) < 1.02V (VM5). The 5V adaptor is now providing the power VOUT. The voltage of PS3 will not track V (BAT) and the dissipation in the charger will increase.
16. Set Load 1 to 1A. Observe that 4.40V < VOUT 5.40V (VM6) and 0.98V < V (PROG) < 1.02V (VM5). Set Load 1 to 0A and set Wall (DC1394, JP3) to “HVBUCK”.
17. Use GUI to enable VOUT1, VOUT2, and VOUT3. Observe that 3.48V < VOUT1 < 3.70V (VM10), 3.28V < VOUT2 < 3.49V (VM8), and 1.74V < VOUT3 < 1.84V (VM9).
18. Set Load 2 to 400mA, Load 3 to 1A, and Load 4 to 400mA. Observe that 3.48V < VOUT1 < 3.70V (VM10), 3.28V < VOUT2 < 3.49V (VM8), and 1.74V < VOUT3 < 1.84V (VM9).
19. Use GUI to set VOUT1, VOUT2, and VOUT3 to minimum. Observe that 1.85V < VOUT1 < 1.96V (VM10), 1.74V < VOUT2 < 1.85V (VM8), and 0.93V < VOUT3 < 0.977V (VM9).
20. Set Load 2 to 0mA, Load 3 to 0mA, and Load 4 to 400mA. Observe that 1.85V < VOUT1 < 1.96V (VM10), 1.74V < VOUT2 < 1.85V (VM8), and 0.93V < VOUT3 < 0.977V (VM9).
21. Use the GUI to disable VOUT1, VOUT2, and VOUT3. Observe that VOUT1 < 0.1V (VM10), VOUT2 < 0.1V (VM8), and < VOUT3 < 0.1V (VM9).




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 3. Proper Measurement Equipment Setup for DC1334A**

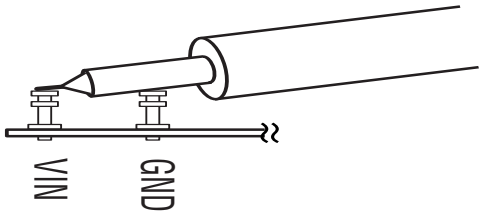



**Figure 4. Measuring Input or Output Ripple**

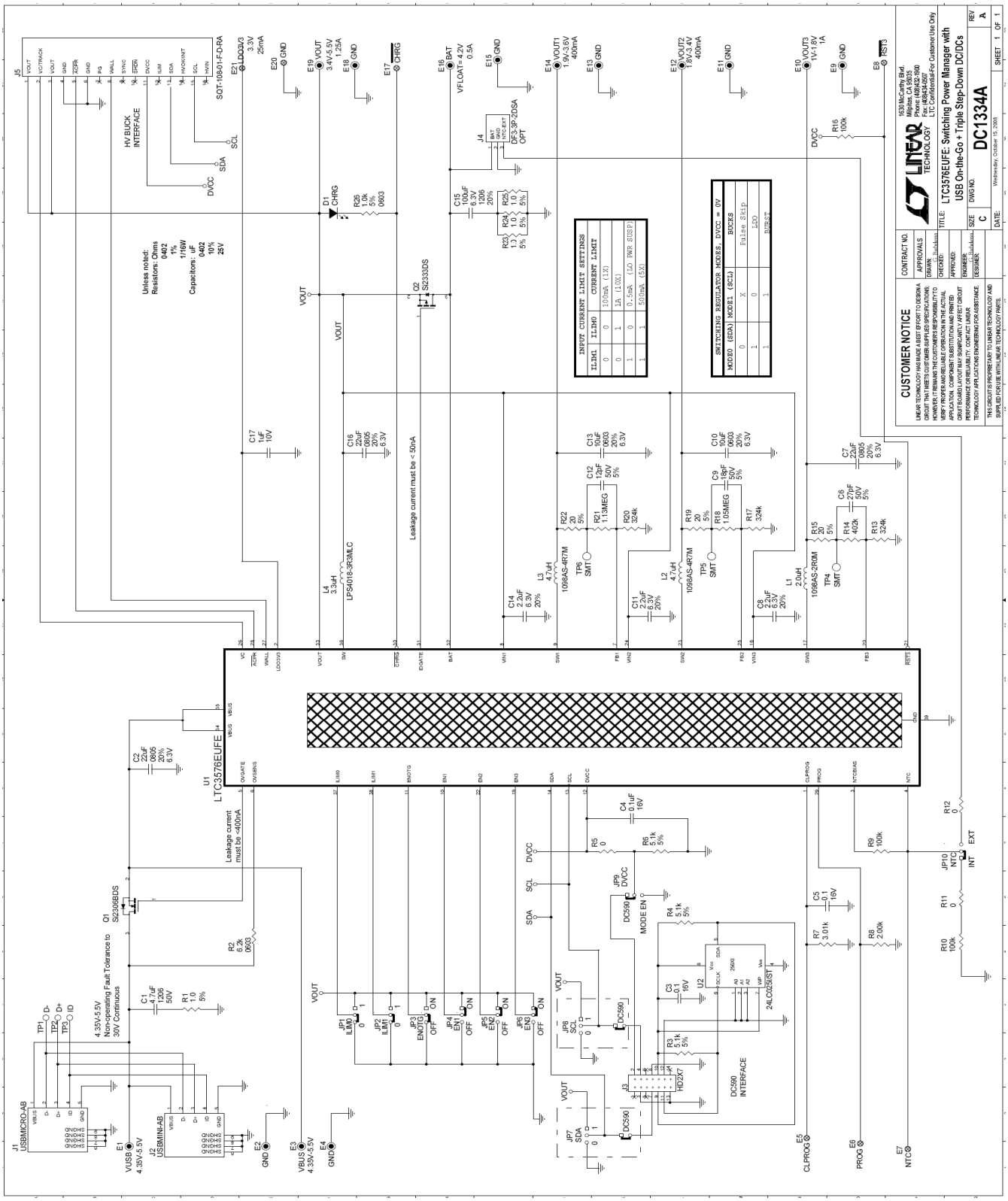



**Figure 5. DC1334A Schematic**

| | Qty | Reference | Part Description | Manufacture / Part # |
|---|---|---|---|---|
| | | **REQUIRED CIRCUIT COMPONENTS:** | | |
| 1 | 3 | C2, C7,C16 | 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 | C6 | CAP, CHIP, COG, 27pF, 5%, 50V, 0402 | VISHAY, VJ0402A270JXAA |
| 4 | 3 | C8,C11,C14 | CAP, CHIP, X5R, 2.2µF, 20%, 6.3V, 0402 | MURATA, GRM155R60J225ME15D |
| 5 | 1 | C9 | CAP, CHIP, COG, 18pF, 5%, 50V, 0402 | VISHAY,VJ0402A180JXAA |
| 6 | 2 | C10,C13 | CAP, CHIP, X5R, 10µF, 10%, 6.3V, 0603 | TDK, C1608X5R0J106K |
| 7 | 1 | C12 | CAP, CHIP, COG, 12pF, 50V, 5%, 0402 | VISHAY, VJ0402A120JXAA |
| 8 | 1 | C17 | CAP, CHIP, X5R, 1.0µF, 10%, 10V, 0402 | TDK, C1005X5R1A105K |
| 9 | 1 | L1 | IND, SMT, 2.0µH, ±20%, 1.9A, 3.0mmX3.2mm | TOKO, 1098AS-2R0M |
| 10 | 2 | L2,L3 | IND, SMT, 4.7µH, ±20%, 1.3A, 3.0mmX3.2mm | TOKO, 1098AS-4R7M |
| 11 | 1 | L4 | IND, SMT, 3.3µH, ±20%, 2.2A, 4.0mmX4.0mm | COILCRAFT, LPS4018-3R3MLC |
| 12 | 1 | Q1 | MOSFET, 30V, 65mΩ, 3.5A, SOT-23 | VISHAY, Si2306BDS |
| 13 | 1 | R2 | RES, CHIP, 6.2kΩ, 1/10W, 5%, 0603 | VISHAY, CRCW06036K20JNED |
| 14 | 1 | R7 | RES, CHIP, 3.01kΩ, 1/16W, 1%, 0402 | VISHAY, CRCW04023K01FKED |
| 15 | 1 | R8 | RES, CHIP, 2.00kΩ, 1/16W, 1%, 0402 | VISHAY, CRCW04022K00FKED |
| 16 | 3 | R13,R17,R20 | RES, CHIP, 324kΩ, 1/16W, 1%, 0402 | VISHAY, CRCW0402324KFKED |
| 17 | 1 | R14 | RES, CHIP, 402kΩ, 1/16W, 1%, 0402 | VISHAY, CRCW0402402KFKED |
| 18 | 1 | R18 | RES, CHIP, 1.05MEGΩ, 1/16W, 1%, 0402 | VISHAY, CRCW04021M05FKED |
| 19 | 1 | R21 | RES, CHIP, 1.13MEGΩ, 1/16W, 1%, 0402 | VISHAY, CRCW04021M13FKED |
| 20 | 1 | U1 | Switching Power Manager + USB On-The-Go + OVP + HV Buck VC Control + 3 Bucks | LINEAR TECH., LTC3576EUFE |
| | | **ADDITIONAL DEMO BOARD CIRCUIT COMPONENTS:** | | |
| 1 | 1 | C1 | CAP, CHIP, X7R, 4.7µF, ±10%, 50V, 1206 | MURATA, GRM31CR71H475KA12L |
| 2 | 2 | C3,C4 | CAP, CHIP, X7R, 0.1µF, ±10%, 16V, 0402 | MURATA, GRM155R71C104KA88 |
| 3 | 1 | C15 | CAP, CHIP, X5R, 100µF, ±20%, 6.3V, 1206 | MURATA, GRM31CR60J107ME39L |
| 4 | 1 | D1 | LED, SMT, GREEN, 1206 | PANASONIC, LN1351CTR |
| 5 | 1 | Q2 | MOSFET, -12V, 35mΩ, -5.3A, SOT-23 | VISHAY, Si2333DS |
| 6 | 4 | R1,R23,R24,R25 | RES, CHIP, 1.0Ω, 1/16W, 5%, 0402 | VISHAY, CRCW04021R00JNED |
| 7 | 3 | R3,R4,R6 | RES, CHIP, 5.1kΩ, 5%, 1/16W, 0402 | VISHAY, CRCW04025K10JNED |
| 8 | 3 | R5,R11,R12 | RES, CHIP, 0Ω, 1/16W, 0402 | VISHAY, CRCW04020000Z0ED |
| 9 | 3 | R9,R10,R16 | RES, CHIP, 100kΩ, 1/16W, 1%, 0402 | VISHAY, CRCW0402100KFKED |
| 10 | 3 | R15,R19,R22 | RES, CHIP, 20Ω, 1/16W, 5%, 0402 | VISHAY, CRCW040220R0JNED |
| 11 | 1 | R26 | RES, CHIP, 1.0kΩ, 5%, 1/10W, 0603 | VISHAY, CRCW06031K00JNED |
| 12 | 1 | U2 | I2C EEPROM | MICROCHIP, 24LC025-I/ST |
| | | **HARDWARE FOR DEMO BOARD ONLY:** | | |
| 1 | 14 | E1,E2,E3,E4,E9,E10,E11,E12 E13,E14,E15,E16,E18,E19 | Turret, 0.09" | MILL-MAX, 2501-2 |
| 2 | 7 | E5,E6,E7,E8,E17,E20,E21 | Turret, 0.061" | MILL-MAX, 2308-2 |
| | 1 | J1 | CONN, USB MICRO-A/B | HIROSE, ZX62-AB-5PA |
| 3 | 1 | J2 | CONN, USB MINI-A/B | MOLEX, 56579-0576 |
| 4 | 1 | J3 | CONN, I2C header | MOLEX, 87831-1420 |
| 5 | 0 | J4-OPT | CONN, Battery | HIROSE, DF3-3P-2DSA |
| | 1 | J5 | CONN, HV interface | SAMTEC, SQT-108-01-F-D-RA |
| 6 | 10 | JP1,JP2,JP3,JP4,JP5, JP6,JP7,JP8,JP9,JP10 | 3 Pin Jumper, 2mm | SAMTEC, TMM-103-02-L-S |
| 7 | 10 | JP1,JP2,JP3,JP4,JP5, JP6,JP7,JP8,JP9,JP10 | 2mm SHUNT | SAMTEC, 2SN-BK-G |
| 8 | 2 | JP11,JP12 | 2 Pin Jumper, 2mm | SAMTEC, TMM-102-02-L-S |
| 9 | 4 | | STAND-OFF, NYLON 0.375" tall (SNAP ON) | KEYSTONE, 8832 (SNAP ON) |

**Figure 6. DC1334A BOM**

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Телефон: 8 (812) 309-75-97 (многоканальный)
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Электронная почта: ocean@oceanchips.ru
Web: http://oceanchips.ru/
Адрес: 198099, г. Санкт-Петербург, ул. Калинина, д. 2, корп. 4, лит. А