



## Power Management Solution Integrated Supercapacitor Charger

By Gerald Tatschl

**MAL219699001E3**

**ENYCAP™**

**Capacitance Range: 1 F to 100 F**

**Voltage Range: 2.3 V to 3.2 V**

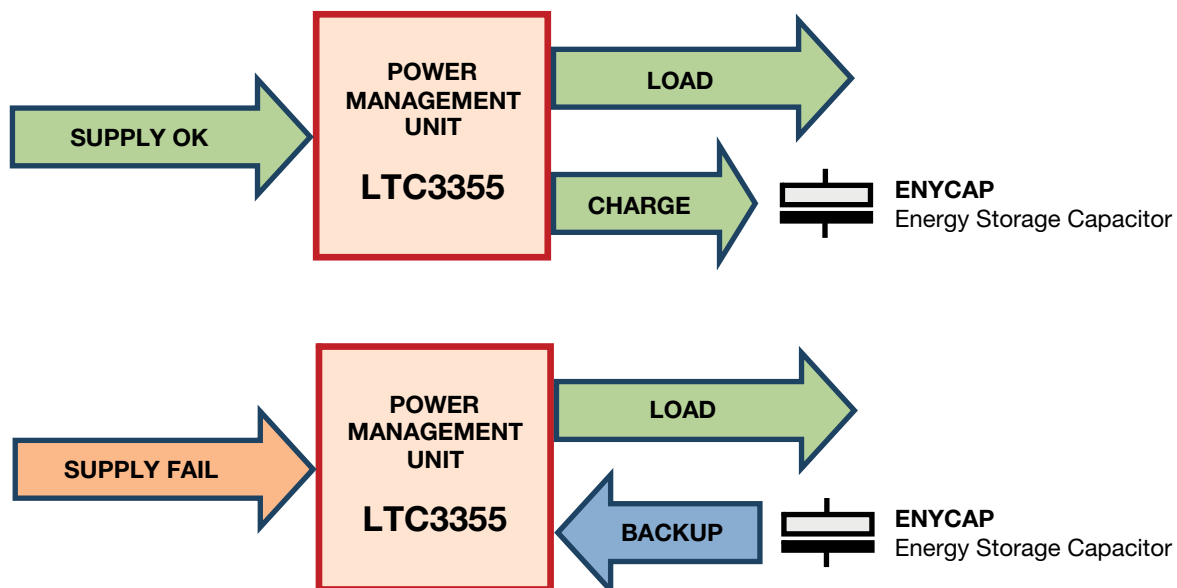
**4 W Backup Power When Input Fails**

### DESCRIPTION

The MAL219699001E3 demonstration circuit is a fully transparent power management solution with a regulated 2 W output and integrated power backup. It provides a DC/DC regulator with a wide power input range from 4.0 V to 20 V and adjustable regulated output between 3.3 V and 5.0 V.

The integrated supercapacitor charger and backup boost regulator is optimized for use with ENYCAP™ supercapacitors as a backup energy storage device. The LTC3355 provides the supercapacitor with a programmable constant charging current from 35 mA to 600 mA and regulated cut-off voltage of 1.8 V to 3.2 V.

When the power input fails, the backup boost regulator supplies regulated output voltage until the charged energy of the supercapacitor is depleted. Power good and related control signals are available.



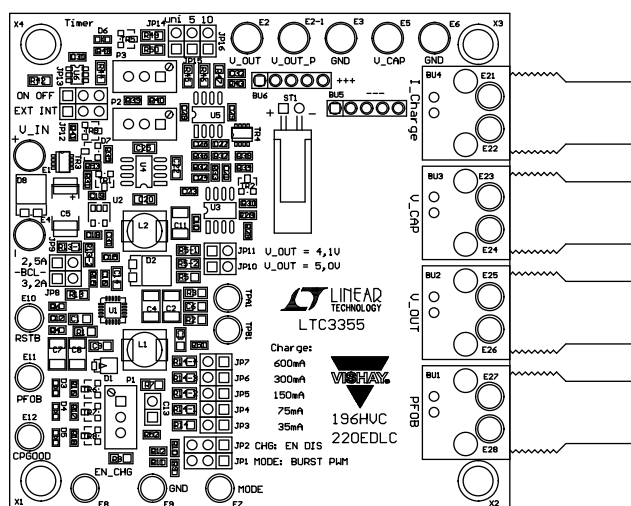
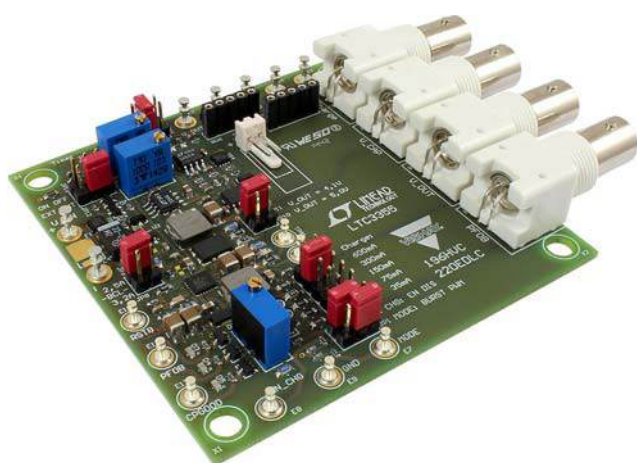
### Note

- For the LTC 3355 datasheet, go to [www.linear.com/product/LTC3355](http://www.linear.com/product/LTC3355)

## Power Management Solution Integrated Supercapacitor Charger

| BOARD CHARACTERISTIC DATA ( $T_A = 25\text{ }^{\circ}\text{C}$ ) |            |                                                                                                       |      |      |      |       |
|------------------------------------------------------------------|------------|-------------------------------------------------------------------------------------------------------|------|------|------|-------|
| PARAMETER                                                        | SYMBOL     | CONDITIONS                                                                                            | MIN. | TYP. | MAX. | UNITS |
| Input voltage range                                              | $V_{IN}$   |                                                                                                       | 4.0  |      | 20.0 | V     |
| Output voltage                                                   | $V_{OUT}$  |                                                                                                       |      |      |      | V     |
| Supercap float voltage                                           | $V_{CAP}$  |                                                                                                       | 1.8  |      | 3.2  | V     |
| Supercap charge current                                          | $I_{CHG}$  |                                                                                                       | 0.03 |      | 0.6  | A     |
| Output current                                                   | $I_{VOUT}$ | $V_{IN} > 10.8\text{ V}$ , $PFI \geq 0.8\text{ V}$ ,<br>$V_{OUT} = \pm 1\%$ , $I_{CHRG} = 0\text{ A}$ |      |      | 1.0  | A     |

### BOARD



### CHARACTERISTIC CHARGING AND POWER BACKUP

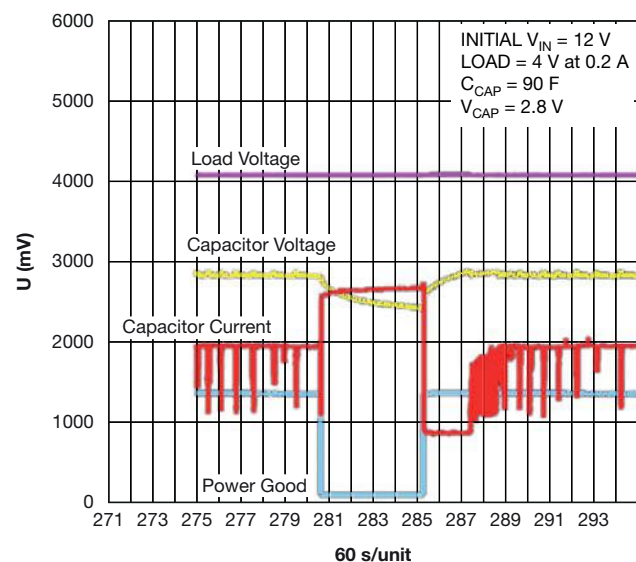


Fig. 1A - 196HVC 90 F - 2.8 V Backup Time > 10 minutes

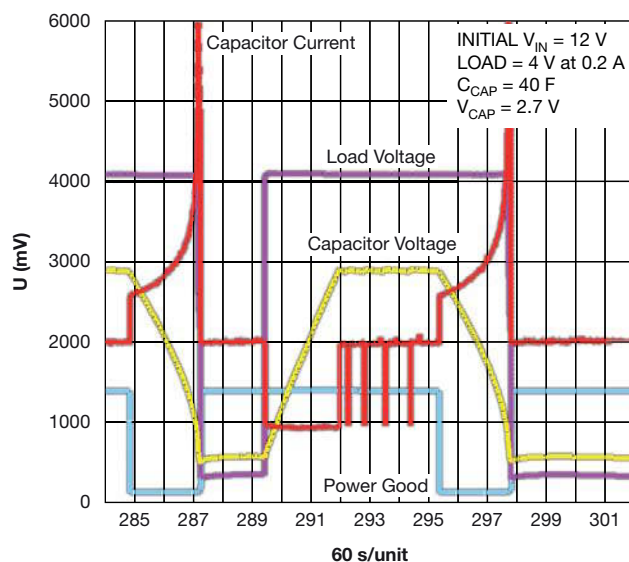


Fig. 1B - 220EDLC 40 F - 2.7 V Backup Time 2.5 minutes



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### QUICK START PROCEDURE

#### Choose Output Voltage

| JP10   | JP11   | V <sub>OUT</sub> |
|--------|--------|------------------|
| Open   | Open   | 3.31 V           |
| Open   | Closed | 4.11 V           |
| Closed | Open   | 5.02 V           |

#### Setup Boost Peak Current

| JP8    | JP9    | IBSTPK |
|--------|--------|--------|
| Open   | Open   | 180 mA |
| Open   | Closed | 2.5 A  |
| Closed | Open   | 3.2 A  |
| Closed | Closed | 5.5 A  |

#### Select Supercapacitor Charge Current

| JUMPER | I <sub>CHG</sub> |
|--------|------------------|
| JP3    | 35 mA            |
| JP4    | 75 mA            |
| JP5    | 150 mA           |
| JP6    | 300 mA           |
| JP7    | 600 mA           |

#### Select Switching Modes

| JP1<br>BRIDGE | MODE            |
|---------------|-----------------|
| None          | See bridge 12   |
| 12            | PWM mode        |
| 23            | BURST mode      |
|               | or remote by E7 |

#### Enable / Disable SCAP Charger

| JP2<br>BRIDGE | MODE            |
|---------------|-----------------|
| None          | See bridge 12   |
| 12            | Disabled        |
| 23            | Enabled         |
|               | or remote by E8 |

#### Power Connections

1. Connect supercapacitor via connector ST1 or turrets E5 and E6 to the board.
2. Connect load via turrets E2-1 (V<sub>OUT\_P</sub>) or E2 (V<sub>OUT</sub>) and E3 (GND) to the board. V<sub>OUT\_P</sub> is the protected output of V<sub>OUT</sub>; it switches off when voltage V<sub>CAP</sub> (supercapacitor) depletes below 1.2 V.
3. Connect supply via turrets E1 (V<sub>IN</sub>) and E4 to the board.

#### Set Up Power Supply Backup Demonstration Mode

On board is a timer to periodically simulate the effect of a supply fail, causing an automatic switch into backup mode to seamlessly provide power to the external load.

By means of JP13, the user can select the supply mode:

| JP13<br>BRIDGE | MODE              |
|----------------|-------------------|
| None           | Timer             |
| 12             | Supply always ON  |
| 23             | Supply always OFF |

## Power Management Solution Integrated Supercapacitor Charger

### LISTING OF SIGNALS

|         |          |                         |            |                                                                                                     |
|---------|----------|-------------------------|------------|-----------------------------------------------------------------------------------------------------|
| V_IN    | In       |                         | E1         | Supply connection 4.0 V to 20 V                                                                     |
| V_OUT   | Out      |                         | E2         | Output voltage to load                                                                              |
| V_OUT_P | Out      |                         | E2-1       | Protected output voltage to load, cut off when V_CAP is less than 1.2 V                             |
| V_CAP   | In / Out |                         | E5         | Positive supercapacitor connection                                                                  |
| GND     | In / Out |                         | E3, E4, E6 | Ground                                                                                              |
| FB_08V  | ---      | JP10, JP11              |            | Programs the output voltage V_OUT (3.31 V, 4.11 V, 5.02 V)                                          |
| IBSTPK  | ---      | JP8, JP9                |            | Boost peak current limit (180 mA, 2.5 A, 3.2 A, 5.5 A)                                              |
| I_CHG   | ---      | JP3, JP4, JP5, JP6, JP7 |            | Programs the V_CAP charge current (35 mA, 75 mA, 150 mA, 300 mA, 600 mA)                            |
| TIMER   | ---      | JP13                    |            | Power management mode: timer / on / off                                                             |
| MODE    | In       | JP1                     |            | This pin sets the buck and boost switching modes. A low is PWM mode, a high is BURST mode operation |
|         |          |                         | E7         | *signal mode decoupled by 1k resistor for remote operation                                          |
| EN_CHG  | In       | JP2                     |            | A high on this pin enables the supercapacitor charger                                               |
|         |          |                         | E8         | *signal mode decoupled by 1k resistor                                                               |
| RSTB    | Out      |                         | E10        | Output is high, when V_OUT is less than 92.5 % of the programmed regulation voltage                 |
| PFOB    | Out      |                         | E11        | Output is low, when V <sub>supply</sub> fails. Boost converter is enabled and powers V_OUT          |
| CPGOOD  | Out      |                         | E12        | Output is low, when V_CAP is higher than 92.5 % of the programmed capacitor voltage                 |

### LISTING OF CONNECTORS

|                |                                                  |
|----------------|--------------------------------------------------|
| BU1 (E27, E28) | PFOB monitor (BNC, turret)                       |
| BU2 (E25, E26) | U_OUT monitor (BNC, turret)                      |
| BU3 (E23, E24) | V_CAP monitor (BNC, turret)                      |
| BU4 (E21, E22) | I_Discharge monitor (BNC, turret)                |
| BU5            | Female connector (GND) to supercapacitor         |
| BU6            | Female connector (V_CAP) to supercapacitor       |
| ST1            | Male connector to supercapacitor (V_CAP and GND) |

**Note**

- Turret positions E21 to E27 are optional and shared with the PNC connector.

### DESCRIPTION OF LEDS

| LED | COLOR  | FUNCTION                        |
|-----|--------|---------------------------------|
| D3  | Red    | Active when RSTB is high        |
| D4  | Red    | Active when PFOB is high        |
| D5  | Red    | Active when CPGOOD is high      |
| D6  | Yellow | Active when timer blocks supply |



## Power Management Solution Integrated Supercapacitor Charger

| PART LIST                 |           |                                           |              |                           |
|---------------------------|-----------|-------------------------------------------|--------------|---------------------------|
| REFERENCE                 | PART TYPE | PART DESCRIPTION                          | MANUFACTURER | PART NUMBER               |
| BU1 to BU4                | BNC       | BNC-connector 90°                         | Molex        | Mouser #523-31-5431-10RFX |
| BU5, BU6                  | BU1x5     | 1x5 pol prec-pinheader RM 2.54 mm         |              |                           |
| C1, C3                    | 100 nF    | 50 V X7R ceramic capacitor 0805           | Vishay       | VJ0805Y104KXAA            |
| C10, C19, C21, C23, C24   | 100 nF    | 25 V X7R ceramic capacitor 0603           | Vishay       | VJ0603Y104KXAA            |
| C13                       | BU1x2     | 1x2 pol. pinheader, RM 2.54 mm            |              |                           |
| C15                       | 220 pF    | 25 V NP0 ceramic capacitor 0603           | Vishay       | VJ0603A221KXAA            |
| C16                       | n.b.      | 25 V NP0 ceramic capacitor 0603           | Vishay       |                           |
| C17                       | 1 nF      | 25 V X7R ceramic capacitor 0603           | Vishay       | VJ0603Y102KXAA            |
| C18                       | n.b.      | 25 V X7R ceramic capacitor 0603           | Vishay       |                           |
| C2, C4, C7, C8, C11       | 22 µF     | 25 V X7R ceramic capacitor 1210           |              |                           |
| C20, C22, C25             | 4.7 µF    | 10 V X7R ceramic capacitor 0805           |              |                           |
| C26 to C32                | 100 nF    | 25 V X7R ceramic capacitor 0603           | Vishay       | VJ0603Y104KXAA            |
| C5                        | 22 µF     | 25 V 593D tantalum capacitor, D case      | Vishay       | 293D226X9025D2T           |
| C6                        | 4.7 pF    | 25 V NP0 ceramic capacitor 0805           | Vishay       | VJ0805A47KXAA             |
| C9, C14                   | 1 µF      | 10 V X7R ceramic capacitor 0805           | Vishay       | VJ0805Y105KXQW1BC         |
| D1                        | SS2P4     | 2 A / 40 V Schottky rectifier, style SMP  | Vishay       | SS2P4-M3/84A              |
| D2                        | SS5P3     | 5 A / 40 V Schottky rectifier, style SMPC | Vishay       | SS5P3-M3/86A              |
| D3 to D5                  | Red       | LED red, TLMS1000, 0603                   | Vishay       | TLMS1000-GS08             |
| D6                        | Yellow    | LED yellow, TLMY1000, 0603                | Vishay       | TLMY1000-GS08             |
| D7                        | 12 V      | 12 V small-signal Zener diodes, SOT-23    | Vishay       | BZX84C12-G3-08            |
| D8                        | n.b.      | 5 A / 40 V Schottky rectifier, style SMPC | Vishay       | SS5P4-M3/86A              |
| E1 to E6, E2-1            | 2501      | PCB pins                                  | Mill-Max     | Mouser #575-2501200800000 |
| E21 to E28                | n.b.      | Turret                                    | Mill-Max     | Mouser #575-2308200440000 |
| E7 to E12, TPA1, TPB1     | 2308      | PCB pins                                  | Mill-Max     | Mouser #575-2308200440000 |
| JP1, JP2, JP12, JP13      | ST1x3     | 1x3 pol. pinheader, RM 2.54 mm            |              |                           |
| JP3 to JP11, JP14 to JP16 | ST1x2     | 1x2 pol. pinheader, RM 2.54 mm            |              |                           |
| L1                        | 22 µH     | 2.5 A high-current inductor, size 2525    | Vishay       | IHLP2525CZER220M11        |
| L2                        | 3.3 µH    | 13 A high-current inductor, size 2525     | Vishay       | IHLP2525BDER3R3M01        |
| P1                        | 470 kΩ    | Potmeter vertical                         | Vishay       | T93YA474KT20              |
| P2                        | 100 Ω     | Potmeter vertical                         | Vishay       | T93YA101KT20              |
| P3                        | 1 MΩ      | Potmeter vertical                         | Vishay       | T93YA105KT20              |
| R1                        | 30 mΩ     | Power Metal Strip® resistor, 1 %, 0805    | Vishay       | WSL0805R0300FTA           |
| R13                       | 5.6 MΩ    | Metal resistor, 1 %, 0805                 | Vishay       | CRCW08055M60FKEA          |
| R13-1                     | 430 kΩ    | Metal resistor, 1 %, 0805                 | Vishay       | CRCW0805430kFKEA          |
| R13-2                     | 330 kΩ    | Metal resistor, 1 %, 0805                 | Vishay       | CRCW0805330kFKEA          |
| R14                       | 1.74 MΩ   | Metal resistor, 1 %, 0805                 | Vishay       | CRCW08051M74FKEA          |
| R14-1                     | 806 kΩ    | Metal resistor, 1 %, 0805                 | Vishay       | CRCW0805806kFKEA          |
| R14-2                     | 402 kΩ    | Metal resistor, 1 %, 0805                 | Vishay       | CRCW0805402kFKEA          |
| R14-3                     | 200 kΩ    | Metal resistor, 1 %, 0805                 | Vishay       | CRCW0805200kFKEA          |
| R14-4                     | 100 kΩ    | Metal resistor, 1 %, 0805                 | Vishay       | CRCW0805100kFKEA          |
| R15                       | 150 kΩ    | Metal resistor, 1 %, 0603                 | Vishay       | CRCW0603150kFKEA          |



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| PART LIST                           |                         |                                                   |              |                       |
|-------------------------------------|-------------------------|---------------------------------------------------|--------------|-----------------------|
| REFERENCE                           | PART TYPE               | PART DESCRIPTION                                  | MANUFACTURER | PART NUMBER           |
| R2                                  | 20 $\Omega$             | Metal resistor, 1 %, 0805                         | Vishay       | CRCW080520R0FKEA      |
| R29, R30                            | 470 k $\Omega$          | Metal resistor, 1 %, 0603                         | Vishay       | CRCW0603470kFKEA      |
| R3                                  | 470 k $\Omega$          | Metal resistor, 1 %, 0805                         | Vishay       | CRCW0805470kFKEA      |
| R31, R35,<br>R38, R41               | 10 k $\Omega$           | Metal resistor, 1 %, 0603                         | Vishay       | CRCW060310k0FKEA      |
| R34                                 | 0 $\Omega$              | Metal resistor, 1 %, 0603                         | Vishay       | CRCW06030000Z0EA      |
| R37, R53                            | 100 k $\Omega$          | Metal resistor, 1 %, 0603                         | Vishay       | CRCW0603100kFKEA      |
| R4                                  | 430 k $\Omega$          | Metal resistor, 1 %, 0603                         | Vishay       | CRCW0603430kFKEA      |
| R40, R43, R48,<br>R51, R52          | 1 k $\Omega$            | Metal resistor, 1 %, 0603                         | Vishay       | CRCW06031k00FKEA      |
| R42                                 | 523 k $\Omega$          | Metal resistor, 1 %, 0805                         | Vishay       | CRCW0805523kFKEA      |
| R44                                 | 1 M $\Omega$            | Metal resistor, 1 %, 0805                         | Vishay       | CRCW08051M00FKEA      |
| R45                                 | 25.5 k $\Omega$         | Metal resistor, 1 %, 0805                         | Vishay       | CRCW080525K5FKEA      |
| R46                                 | 100 k $\Omega$          | Metal resistor, 1 %, 0805                         | Vishay       | CRCW0805100kFKEA      |
| R47                                 | 11 k $\Omega$           | Metal resistor, 1 %, 0805                         | Vishay       | CRCW080511k0FKEA      |
| R49                                 | 220 k $\Omega$          | Metal resistor, 1 %, 0805                         | Vishay       | CRCW0805220kFKEA      |
| R5, R50                             | 150 k $\Omega$          | Metal resistor, 1 %, 0805                         | Vishay       | CRCW0805150kFKEA      |
| R5-1                                | 470 k $\Omega$          | Metal resistor, 1 %, 0805                         | Vishay       | CRCW0805470kFKEA      |
| R5-2                                | 430 k $\Omega$          | Metal resistor, 1 %, 0805                         | Vishay       | CRCW0805430kFKEA      |
| R6, R11, R12,<br>R32, R33, R36      | 100 k $\Omega$          | Metal resistor, 1 %, 0603                         | Vishay       | CRCW0603100kFKEA      |
| R7                                  | 680 k $\Omega$          | Metal resistor, 1 %, 0805                         | Vishay       | CRCW0805680kFKEA      |
| R8                                  | 390 k $\Omega$          | Metal resistor, 1 %, 0805                         | Vishay       | CRCW0805390kFKEA      |
| R9, R10,<br>R16 to R18,<br>R28, R39 | 1 k $\Omega$            | Metal resistor, 1 %, 0603                         | Vishay       | CRCW06031k00FKEA      |
| ST1                                 | PSL2L                   | 2 pol connector 90°                               |              |                       |
| TR1, TR2                            | BC846B                  | NPN-transistor SOT-23                             |              | Mouser #771-BC846B235 |
| TR3, TR4                            | SIS407DN                | 25 A / 20 V p-channel MOSFET,<br>PowerPak-1212    | Vishay       | SIS407DN-T1-GE3       |
| TR5                                 | BSS138                  | N-channel MOSFET, SOT-23                          |              |                       |
| TR6 to TR9                          | MMUN2111                | Digital PNP transistor, SOT-23                    |              |                       |
| U1                                  | LTC3355EUF              | 20 V, 1 A buck DC/DC                              | LT           |                       |
| U2                                  | MIC5235-5.0YM5          | 5.0 V / 150 mA linear regulator, SOT-23/5         | Micrel       |                       |
| U3                                  | ACS712<br>ELCTR-05B-T   | 5 A Hall-effect-based linear current<br>sensor IC | Allegro      |                       |
| U4                                  | LTC1044CS8              | Charge pump, SO-8                                 | LT           |                       |
| U5                                  | LT1490ACS8              | Rail-to-rail op amp, SO-8                         | LT           |                       |
| U6                                  | LTC6995CS6-1#TR<br>MPBF | Long timer oscillator, SOT-23/6                   | LT           |                       |
| X1 to X4                            | 8832                    | Stacking spacer                                   | Keystone     | Mouser #534-8832      |
| X6                                  | 196HVC                  | Vishay logo                                       |              |                       |

# Power Management Solution

## Integrated Supercapacitor Charger

### SCHEMATIC DIAGRAM

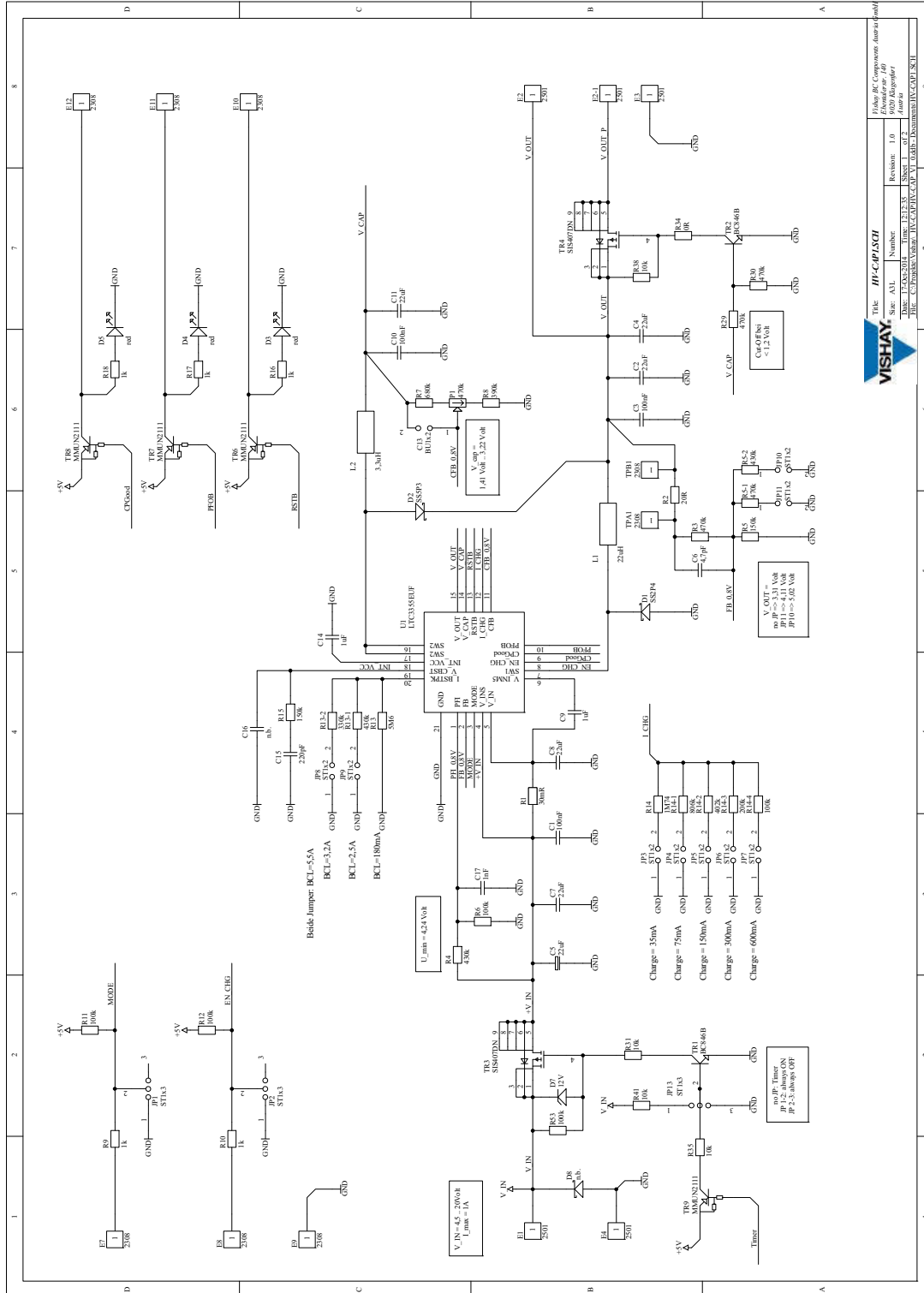


Fig. 2A

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## Integrated Supercapacitor Charger

### SCHEMATIC DIAGRAM

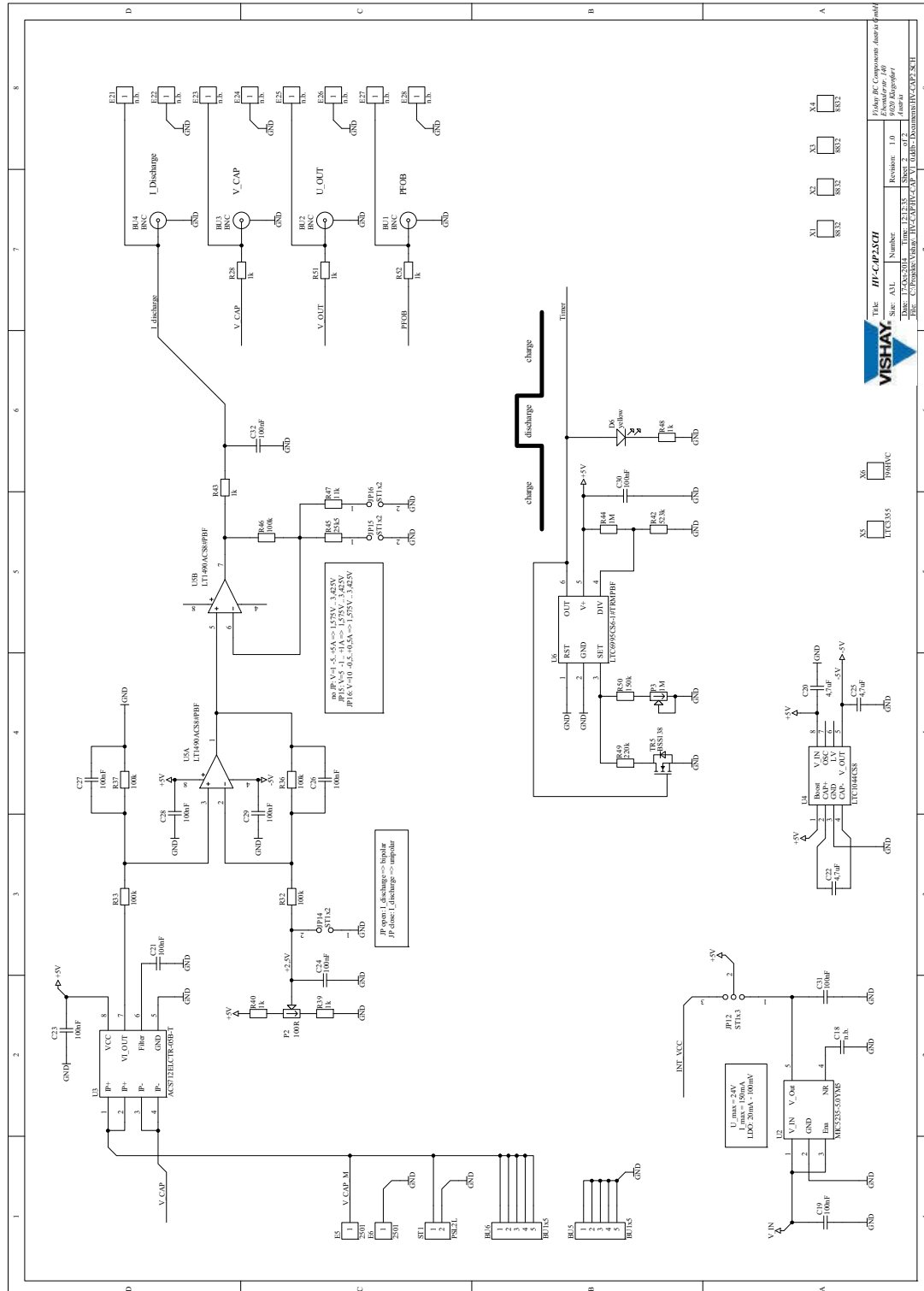


Fig. 2B



## Power Management Solution Integrated Supercapacitor Charger

### INCLUDED MATERIALS

ENYCAP Evaluation Kit™ with LTC3555 from Linear Technology

1. Board: 80 mm x 80 mm
2. ENYCAP 196HVC 90 F - 2.8 V
3. ENYCAP 196HVC 15 F - 2.8 V
4. ENYCAP 220EDLC 40 F - 2.7 V
5. This document

Thank you for using and buying the ENYCAP evaluation board. If you need further information, please contact:

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