

# LP3971 USB Evaluation Board

National Semiconductor  
Application Note 1620  
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## General Description

The LP3971 Flex PMU is a complete power management IC designed for advanced applications processors. It contains 5 low noise low dropout regulators, 3 DC/DC buck converters, a backup battery charger, real time clock supply regulator [RTC], 2 GPO's and high speed I<sup>2</sup>C serial interface to program individual regulator output voltages as well as offer on/off control. This USB evaluation board features independent USB powering, virtual voltmeter bank all in a compact demonstration platform.

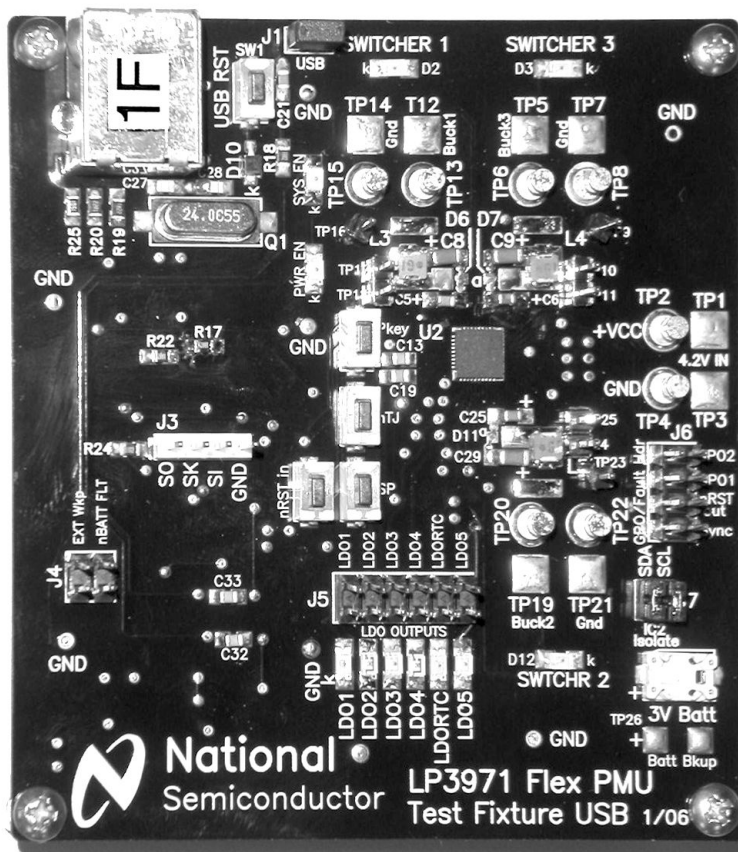
## Key Features

- 2.7V to 5.5V input voltage range
- Programmable V<sub>OUT</sub> 0.8V–3.3V
- Up to 95% efficiency
- ±3% output voltage accuracy
- 1.5A output current [bucks]

## Applications

- Personal Media Players
- Smart Phones
- PDA Phones
- Digital Cameras

## LP3971 Evaluation Board Version F



30018201

## Evaluation Board/Kit Overview

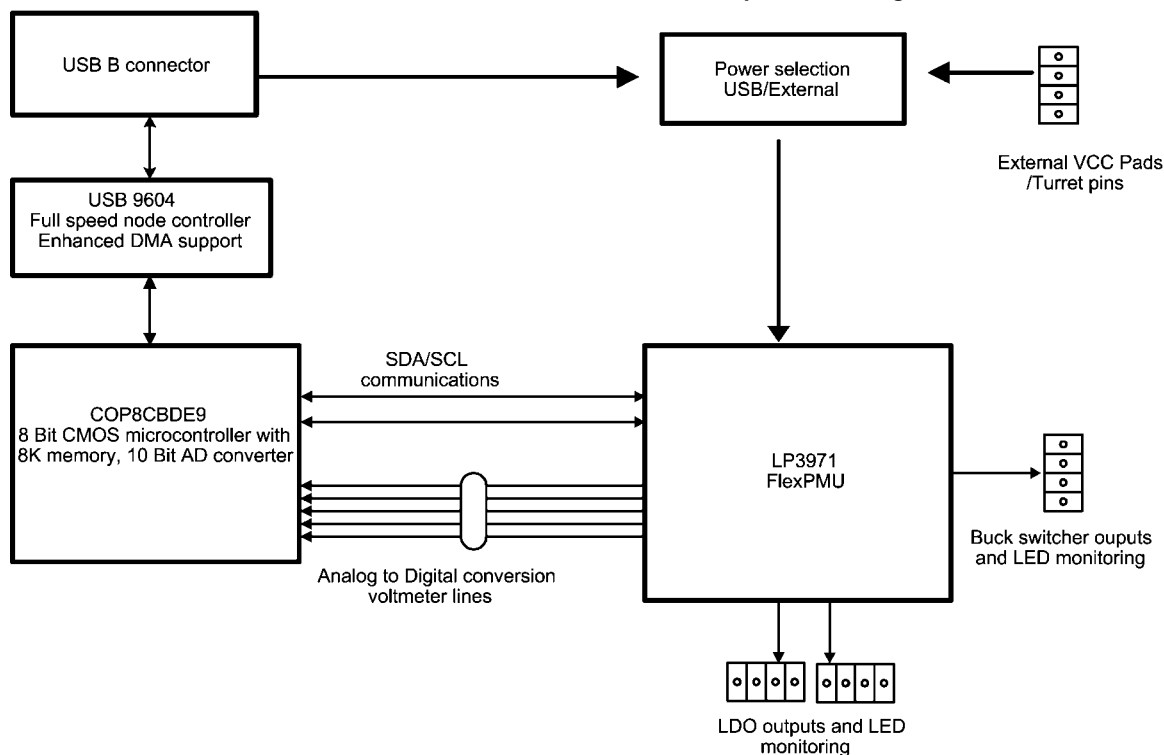
The LP3971 Evaluation Board supports complete functional evaluation of the power management IC. The functions of the chip are controlled by the I<sup>2</sup>C interface. The I<sup>2</sup>C interface on the rev A, B, C, E, F and later USB boards are driven via a COP8 microprocessor which supports a connection via the USB port and offers chip powering and virtual software voltage measurement of all regulators. In addition, the LP3971 can be powered directly through the USB port for full function. If high current Buck testing is desired, an external LI ION cell or PS capable of supplying 2 amps will need to be connected to the appropriate connector.

The evaluation board/kit consists of:

- LP3971 Flex\_PMU device soldered down in LQA-40 pin 5X5 LD package

- Full USB interface
- LED LDO monitoring with current limit resistors [selectable]
- External power LDO, Buck output and main battery/supply connectors offered in heavy duty turret pins and solder pads
- Socket for back-up battery
- Users guide
- Codeloader Software version 1.2.0 or greater [may be sent via email]

LP3971 Flex\_PMU USB Evaluation Board Block Operational Diagram



30018202

## Pin Description 5X5 Package

| Pin # | Name                   | I/O | Type | Description                                             |
|-------|------------------------|-----|------|---------------------------------------------------------|
| 1     | PKEY                   | I   | D    | CPU Wakeup Input                                        |
| 2     | nTJ                    | I   | D    | CPU Wakeup Input                                        |
| 3     | SP                     | I   | D    | CPU Wakeup Input                                        |
| 4     | EXT_WAKEUP             | O   | D    | CPU Wakeup Input                                        |
| 5     | FB1, Feedback Buck1    | I   | A    | Buck 1 Feedback                                         |
| 6     | $V_{IN1} = V_{Batt}$   | I   | P    | Battery Input for Powering Internal Circuits and LDO1–3 |
| 7     | LDO_V <sub>OUT_1</sub> | O   | P    | LDO1 Output                                             |
| 8     | LDO_V <sub>OUT_2</sub> | O   | P    | LDO2 Output                                             |
| 9     | nRST In                | I   | D    | Chip Reset Input                                        |
| 10    | LDO GND 1              | G   | G    | Ground                                                  |

| Pin # | Name                            | I/O | Type | Description                        |
|-------|---------------------------------|-----|------|------------------------------------|
| 11    | LDO <sub>REF</sub> Bypass       | O   | A    | Bypass Capacitor for Reference     |
| 12    | LDO_V <sub>OUT-3</sub>          | O   | P    | LDO3 Output                        |
| 13    | LDO_V <sub>OUT-4</sub>          | O   | P    | LDO4 Output                        |
| 14    | V <sub>IN</sub> LDO_4           | I   | P    | Input Power for LDO4               |
| 15    | Back-Up Battery V <sub>IN</sub> | I   | P    | Back Up Battery Input              |
| 16    | LDO_V <sub>OUT-0</sub> (RTC)    | O   | P    | LDO-RTC Output                     |
| 17    | nBatt_FLT                       | O   | D    | Main Battery Fault Output          |
| 18    | PGND Buck2                      | G   | G    | Ground                             |
| 19    | V <sub>OUT</sub> Buck2          | O   | P    | Buck Switcher 2 Output             |
| 20    | V <sub>IN</sub> Buck2           | I   | P    | Buck Switcher 2 Battery Input      |
| 21    | SDA                             | I/O | D    | I <sup>2</sup> C Data Line         |
| 22    | SCL                             | I   | D    | I <sup>2</sup> C Clock Input       |
| 23    | FB2, Feedback Buck2             | I   | A    | Buck Switcher 2 Feedback           |
| 24    | nRST Out                        | O   | D    | Reset Output                       |
| 25    | LDO_V <sub>OUT-5</sub>          | O   | P    | LDO5 Output                        |
| 26    | V <sub>IN2</sub> (LDO 5 Only)   | I   | P    | Battery Input Power for LDO5       |
| 27    | VDDA                            | I   | P    | Analog Power Input                 |
| 28    | FB3, Feedback Buck3             | I   | A    | Buck Switcher 3 Feedback           |
| 29    | GPIO1                           | I/O | D    | General Purpose I/O #1             |
| 30    | GPIO2                           | I/O | D    | General Purpose I/O #2             |
| 31    | V <sub>IN</sub> Buck3           | I   | P    | Buck Switcher 3 Battery Input      |
| 32    | V <sub>OUT</sub> Buck3          | I   | P    | Buck Switcher 2 Output             |
| 33    | PGND Buck3                      | G   | G    | Buck3 NMOS Power Ground            |
| 34    | Buck 1 2 & 3 AVSS/NCHBLK        | G   | G    | Buck1, 2, 3 Analog Ground          |
| 35    | SYNC (Buck Clock Input)         | I   | D    | Buck Switcher External Clock Input |
| 36    | Sys_En                          | I   | D    | Power Domain Enable                |
| 37    | Pwr_En                          | I   | D    | Power Domain Enable                |
| 38    | PGND Buck1                      | G   | G    | Buck1 NMOS Power Ground            |
| 39    | V <sub>OUT</sub> Buck1          | O   | P    | Buck Switcher 1 Output             |
| 40    | V <sub>IN</sub> Buck1           | I   | P    | Buck Switcher 1 Battery Input      |

A: Analog Pin

D: Digital Pin

G: Ground Pin

P: Power Pin

I: Input Pin

I/O: Input/Output

O: Output Pin

## Operating Instructions

The following instructions give general instructions for use of LP3971 with the evaluation board. Practice standard ESD protection (ground cable) to prevent any unwanted damaging ESD events.

1. Check that the jumpers are in default settings (jumpers are introduced later on this document).
2. Load version 1.2.0 or later of the codeloader program into PC.
3. Connect the USB cable [standard USB AB cable] from the USB connector to PC port.
4. Open the codeloader program up, verify that "USB" port has been selected.
5. Verify that successful communications link has been established by toggling "READ ALL".
6. If there is no communication, key the USB RST [SW1] switch once on the board for reboot.
7. If the voltmeter monitoring function is desired, select "POLL STATUS".
8. LDO/buck outputs may be monitored directly off the appropriate header output pins.
9. Note that for full load testing, an external PS must be connected to TP1/TP2 and jumper J1 must be removed. This is because the USB port source spec is limited to 500 mA and removing the jumper will disconnect the USB supply.
10. PWR EN/SYS En is selectable via codeloader software assignment.
11. Hardware reset can be accomplished by pressing the nREST\_In momentary switch.
12. Battery backup is possible by inserting appropriate rechargeable cell into supplied holder.
13. Switches PKEY, nTJ, and SP, are provided for use in normal evaluation mode.

# List of Components

March 03, 2006

| Item | Qty. | Reference                                                                       | Value                | Pkg.      | Manuf.      | Part Number           |
|------|------|---------------------------------------------------------------------------------|----------------------|-----------|-------------|-----------------------|
| 1    | 5    | C1, C21, CC, CD, CF1                                                            | 10 $\mu$ F           | 0805      | Panasonic   | ECJ2FF1A106Z          |
| 2    | 2    | C2, C3                                                                          | 100 $\mu$ F          | 3528-21   | Kemet       | T520B107M006ASE040    |
| 3    | 8    | C4, C7, C13, C15, C16, C31, CA, CB                                              | 1 $\mu$ F            | 0805      | Kemet       | C0805C105K4RACTU      |
| 4    | 6    | C5, C6, C8, C9, C25, C29                                                        | 10 $\mu$ F           | 1206      | Taiyo-Yuden | JMK316BJ106M          |
| 5    | 6    | C14, C19, C20, C23, C24, C26                                                    | 0.47 $\mu$ F         | 0805      | TDK         | C2012X7R1E474K        |
| 6    | 2    | C17, C18                                                                        | 47 $\mu$ F           | 0805      | Murata      | GRM2195C2A470JZ01D    |
| 7    | 4    | C22, C30, C32, C33                                                              | 0.1 $\mu$ F          | 0805      | Murata      | GRM21BR71E104KA01L    |
| 8    | 2    | C27, C28                                                                        | 15 pF                | 0805      | Yageo       | 0805CG150J9B200       |
| 9    | 1    | BT2                                                                             | Battery Holder       | SMT       | Seiko       | BH0414                |
| 10   | 1    | NOT INSTALLED                                                                   | Backup Battery       | Micro4    | Seiko       | MS412F                |
| 11   | 4    | D6, D7, D10, D11                                                                | Schottky             | PM 457    | On Semi     | MBRM120LT3            |
| 12   | 2    | D8 (PWR EN), D9 (SYS EN)                                                        | Green LED            | 1206      | Lumex       | SML-LX1206GC-TR       |
| 13   | 9    | LDO1(D13), LDO2(D14), LDO3(D18), LDO4(D17), LD05(D19), LDORTC(D16), D2, D3, D12 | Red LED              | 1206      | Lumex       | SML-LX1206IC-TR       |
| 14   | 2    | L1, L2                                                                          | 1 $\mu$ H Inductor   | 0805      | TDK         | MLF2012A1R0K          |
| 15   | 3    | L3, L4, L5                                                                      | 2.2 $\mu$ H Inductor | SMT       | Toko        | FDSE0312              |
| 16   | 1    | Q1                                                                              | XTAL 24 MHz 18 pF    | SMD       | Citizen     | HCM49-24.000MABJT     |
| 17   | 7    | R1, R2, R23, R31, R32, R33, R34                                                 | 330 $\Omega$         | 0805      | SEI         | 807065R330            |
| 18   | 1    | R8                                                                              | 100 $\Omega$         | 0805      | NIC         | NRC10J101TR           |
| 19   | 1    | R9                                                                              | 49.9 $\Omega$        | 0805      | Rohm        | MCR10EZHF49R9         |
| 20   | 10   | R10, R11, R12, R18, R22, R24, R26, R27, R36, R37                                | 10K                  | 0805      | Yaego       | 9C08052A1002FKHFT     |
| 21   | 1    | R12                                                                             | 0 $\Omega$           | 0805      | Yageo       | 9C08052A0R00JLHFT     |
| 22   | 4    | R15, R16, R28, R29                                                              | 133 $\Omega$         | 0805      | Rohm        | MCR10EZHF1330         |
| 23   | 2    | R19, R20                                                                        | 22.1 $\Omega$        | 0805      | Vishay-Dale | CRCW080522R1ERT1      |
| 24   | 1    | R21                                                                             | 1M                   | 0805      | Yageo       | 9C08052A1004JLH       |
| 25   | 1    | R25                                                                             | 1.5k                 | 0805      | Yageo       | 9C08052A1501FKH       |
| 26   | 1    | D1                                                                              | 45.3 $\Omega$        | 0805      | Vishay-Dale | CRCW080545R3F100      |
| 27   | 5    | S1, S2, S3, S4, SW1                                                             | Touch Switch         | SMD       | Panasonic   | EVQ-PJU04K            |
| 28   | 1    | U1                                                                              | 3.3V Regulator       | SOT-23 5  | NSC         | LP2981AIM5-3.3        |
| 29   | 1    | U2                                                                              | PMU                  | SQF-40    | NSC         | LP3971SQ              |
| 30   | 1    | U3                                                                              | USB Controller       | SOIC 28   | NSC         | USBN9604-28M          |
| 31   | 1    | U4                                                                              | Microcontroller      | TSSOP 48  | NSC         | COP8CBE9IMT9          |
| 32   | 1    | U5                                                                              | 2V Regulator         | SOT-23 5L | NSC         | LP3984IMF-2.0         |
| 33   | 1    | U6                                                                              | Voltage Converter    | SOT-23-6  | NSC         | LM2664M6              |
| 34   | 1    | J1                                                                              | 100 mil Header       | 2 pos     | Amp         | 1 X 2 (4-103239-0-02) |
| 35   | 1    | J2                                                                              | USB Receptacle       | 4 pos     | FCI         | 61729-0010B           |
| 36   | 1    | J3                                                                              | 100 mil Header       | 4 pos     | Molex       | 1 X 4 (22-10-2041)    |
| 37   | 1    | J4                                                                              | 100 mil Header       | 4 pos     | Amp         | 2 X 2 (4-103240-0-02) |
| 38   | 1    | J5                                                                              | 100 mil Header       | 12 pos    | Amp         | 2 X 5 (4-103240-0-06) |
| 39   | 1    | J6                                                                              | GPO/LDO Headers      | 8 pos     | Amp         | 2 X 4 (4-103186-0-04) |
| 40   | 1    | J7                                                                              | 2 mm Header          | 4 pos     | Sullins     | 2 X 2 (PRPN022MAMP)   |

| Item | Qty. | Reference                                                 | Value            | Pkg.    | Manuf.       | Part Number         |
|------|------|-----------------------------------------------------------|------------------|---------|--------------|---------------------|
| 41   | 10   | TP9, TP10, TP11, TP16, TP17, TP18, TP23, TP24, TP25, TP26 | Test Points      | 1 pos   | Amp          | 1 X (4-103185-0-01) |
| 42   | 8    | TP2, TP4, TP6, TP8, TP13, TP15, TP20, TP22                | Turrett Terminal | 0.109"L | Keystone     | 1502-2              |
| 43   | 1    | LP3971 version F Fab                                      | Bare Board       | 4 Layer | Rainbow Labs | LP3971-F            |

## Powering and Jumpers Selection

The LP3971 USB evaluation platform offers several power connectors. These connectors are outlined in the table below. In addition, the Evaluation board has jumpers for special

modes and stand-alone use. The default jumper settings are valid in normal operation and are also outlined below.

| Component | Use                                                                           | Comment                                                  |
|-----------|-------------------------------------------------------------------------------|----------------------------------------------------------|
| J5-1      | Output for LDO1                                                               | Outside Pin of Connector is Grd                          |
| J5-2      | Output for LDO2                                                               | Outside Pin of Connector is Grd                          |
| J5-3      | Output for LDO3                                                               | Outside Pin of Connector is Grd                          |
| J5-4      | Output for LDO4                                                               | Outside Pin of Connector is Grd                          |
| J5-6      | Output for LDO5                                                               | Outside Pin of Connector is Grd                          |
| J5-5      | Output for RTC [Real Time Clock]                                              | Outside Pin of Connector is Grd                          |
| J4-1      | Input for External Wakeup                                                     | Outside Pin of Connector is Grd                          |
| J4-2      | Output for nBATT Fault                                                        | Outside Pin of Connector is Grd                          |
| J6-2      | Output for nREST                                                              | Outside Pin of Connector is Grd                          |
| J6-3      | GPO 1 Output                                                                  | Outside Pin of Connector is Grd                          |
| J6-4      | GPO 2 Output                                                                  | Outside Pin of Connector is Grd                          |
| J3-1      | Cop8 Microwire SO                                                             | Used for Micro Flash Only                                |
| J3-2      | Cop8 Microwire SK                                                             | Used for Micro Flash Only                                |
| J3-3      | Cop8 Microwire SI                                                             | Used for Micro Flash Only                                |
| J3-4      | Cop8 Grd                                                                      | Used for Micro Flash Only                                |
| TP12-13   | Output for Swicher Buck 1                                                     | GRD is TP12-13                                           |
| TP19-20   | Output for Swicher Buck 2                                                     | GRD is TP21-22                                           |
| TP5-6     | Output for Swicher Buck 3                                                     | GRD is 7-8                                               |
| USB       | USB Connector                                                                 | Connect to the PC Via Supplied Cable                     |
| J1        | Power Usage Selson                                                            | Place Jumper for USB, NO JUMPER for External Power Input |
| TP1-2     | Connect External V <sub>CC</sub> Supply Here 3.5V–5V for High Current Testing | Doubles for LI-ION cell Input                            |

## Demonstration Software Window

The demonstration software enables read and write to LP3971's internal registers through PC's USB port. All the user controllable registers are usable through the software. Installation: Run the codeloader for LP3971 version 1.2.0 or greater.

After startup the user can verify that successful USB communication has been established by selecting "Read All", the default programmed voltages should appear.

LDO's can be enabled and disabled by clicking mouse left button on the square close to each LDO voltage slider. Changing the virtual slider changes the LDO voltage. After the WRITE button is pressed subsequent LDO changes are applied if the 'autowrite' feature is disabled.

Note 'Autowrite' enabled is default. In the case of the buck control, an option for 'hold' or 'go' can be selected. Note voltage will not change until the 'go' selection is made.

The virtual voltmeters can be activated by selecting 'Poll Status', after which an A to D conversion is read and displayed for each subsequent LDO and Buck output. Note that this feature is meant to be a general measurement and "may" be subject to variations due to operations noise.

Since there is a bi-directional SDA feature, any register and its contents can be determined by entering the desired register address and selecting 'Read'. In addition, any corresponding register may be written directly to via the 'Store' selection. All virtual sliders can be updated via the 'Read All' Tab. Direct register control is possible by entering the desired address and value followed by a 'Store' command.

**LP3971 Control Panel (ver 1.2.2)**

File Settings Help



Direct Register Access

Addr (HEX): 0 Store Addr (HEX): 0 Read

Data: 7 6 5 4 3 2 1 0 Data (BIN):

Registers Profile

0: Save Load Def

1: Save Load Def

Quit

Interface Port: USB

**Main Control**

**LDO / BUCK Output Enable Control**

|      |      |      |      |      |       |       |       |
|------|------|------|------|------|-------|-------|-------|
| LDO1 | LDO2 | LDO3 | LDO4 | LDO5 | BUCK1 | BUCK2 | BUCK3 |
| On   | On   | On   | On   | On   | On    | On    | On    |
| Ok   | Ok   | Ok   | Ok   | Ok   | Ok    | Ok    | Ok    |

2.99 V 2.98 V 2.98 V 1.29 V 1.09 V 1.41 V 3.00 V 1.81 V

**LDO Output Voltage Selection**

|       |       |       |        |        |
|-------|-------|-------|--------|--------|
| LDO1  | LDO2  | LDO3  | LDO4   | LDO5   |
| 3.0 V | 3.0 V | 3.0 V | 1.30 V | 1.10 V |

**BUCK Output Voltage Selection**

|        |           |        |           |        |           |
|--------|-----------|--------|-----------|--------|-----------|
| Hold   | Force PWM | Hold   | Force PWM | Hold   | Force PWM |
| BUCK1  | RAMP      | BUCK2  | RAMP      | BUCK3  | RAMP      |
| 1.40 V | 1.40 V    | 3.00 V | 3.00 V    | 1.80 V | 1.80 V    |
| V1     | V2        | V1     | V2        | V1     | V2        |

**Charger Control**

Charger Current: 500 uA

Threshold Voltage: 2.8/3.0 V

☐ Enable Charger  
☐ Enable Threshold  
☐ Disable Backup Battery  
☐ Enable precharge  
☒ GPIO1 pin as Enable Charger  
☐ Shut Charger to VDDA

**Control / Status bits and I/O pins**

☐ Enable LDO5 from SYSEN to PWREN  
☒ Enable Buck2 by SYS\_EN  
☒ Enable LDO4 by SYS\_EN  
☒ Enable neg-polarity for SPARE input  
☐ Bypass LDO\_RTC voltage tracking  
☐ Soft PWR\_EN Temp: Ok SYS\_EN delay: Bypass

☐ Bypass SYS\_EN pin  
☐ Enable ext clock for bucks  
☐ Enable Spread Spectrum (SS)  
☒ Set SS modulation: 2 or 10 kHz

GPIO1: HZ IN LO HI 0  
 GPIO2: HZ IN LO HI 0  
 Pin nCHG\_EN: 1 Pin nTEST\_JIG: 1  
 Pin SPARE: 1 Pin PWR\_ON: 0  
 Wakeup reason: Pin nTEST\_JIG

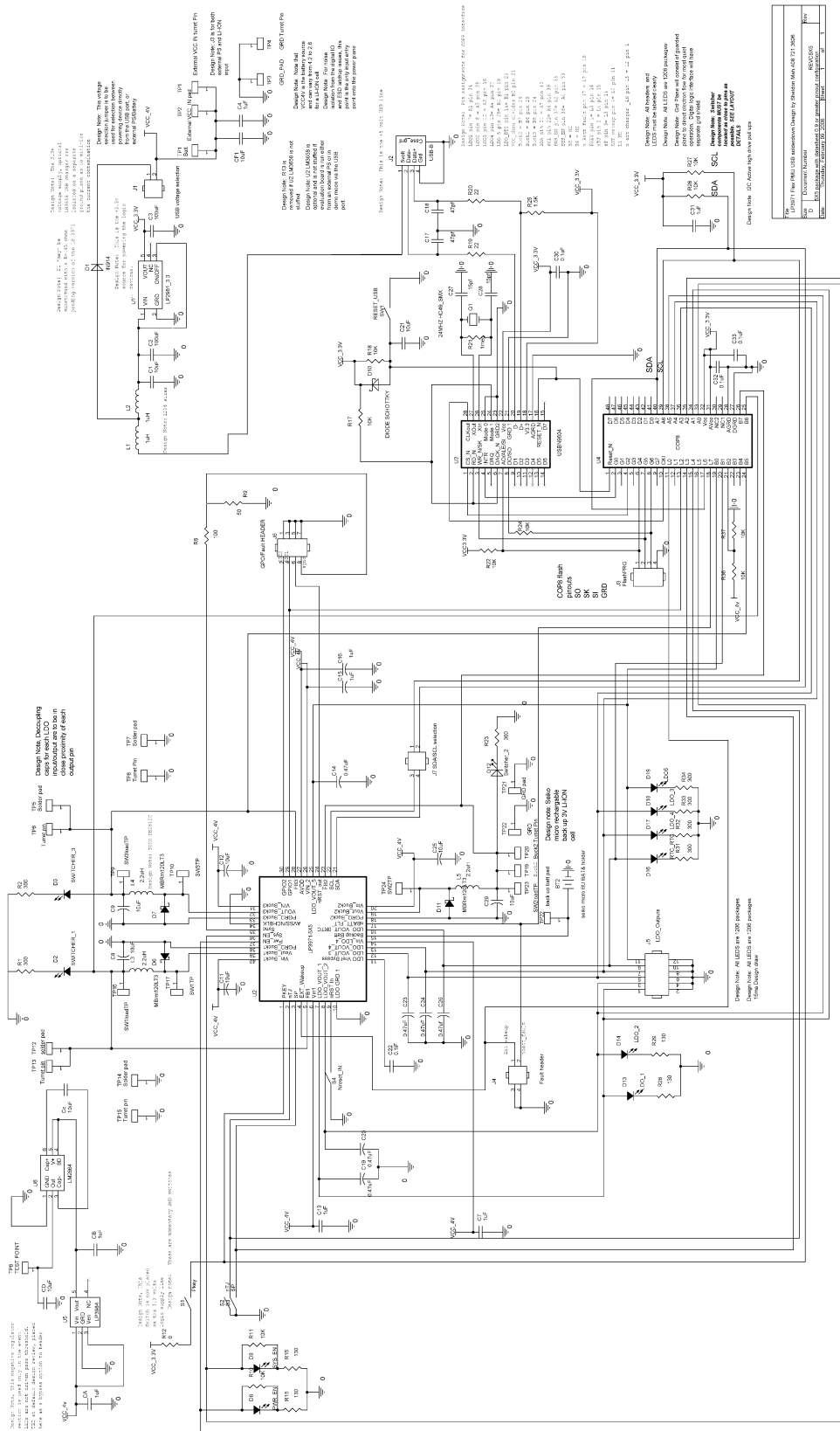
☒ Set SYS\_EN pin  
☐ Set EXT\_WAKEUP pin  
☒ Set PWR\_EN pin  
☐ Set nBATT\_FLT pin

Measure Defaults ReadAll WriteAll

☒ Auto Write  
☒ Poll status (1s)

PC I/F: USB CHIP I/F: PC @ 34h OK VDD=1.84 V LDO\_RTC=3.02 V 11:95

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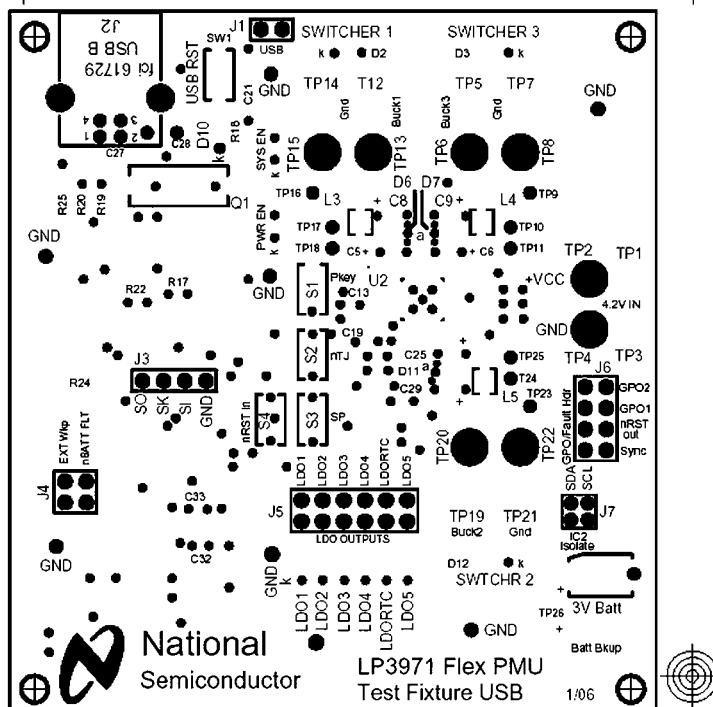


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## Layout Details

## Top Silkscreen

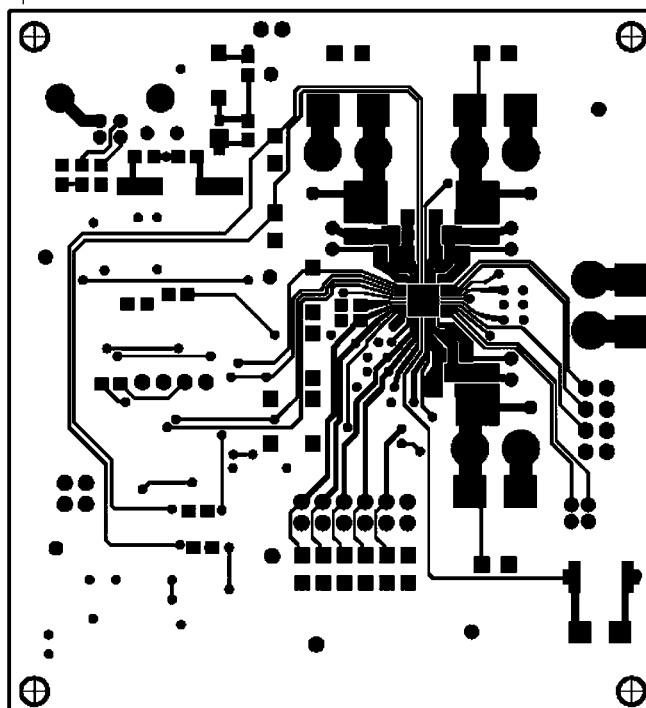
## TOP SILKSCREEN LEGEND



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## Top Trace

TOP (Component Side) Layer 1

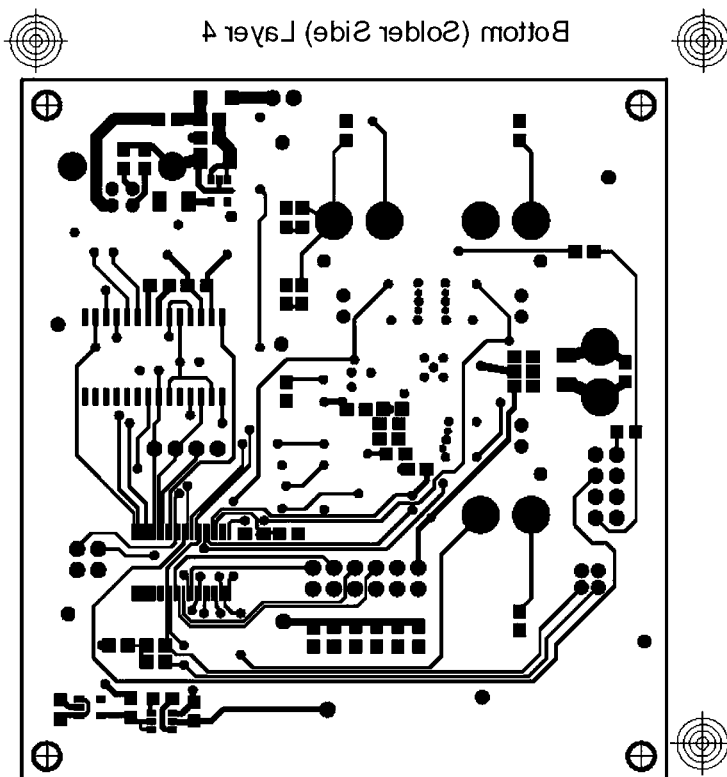


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### Bottom Trace

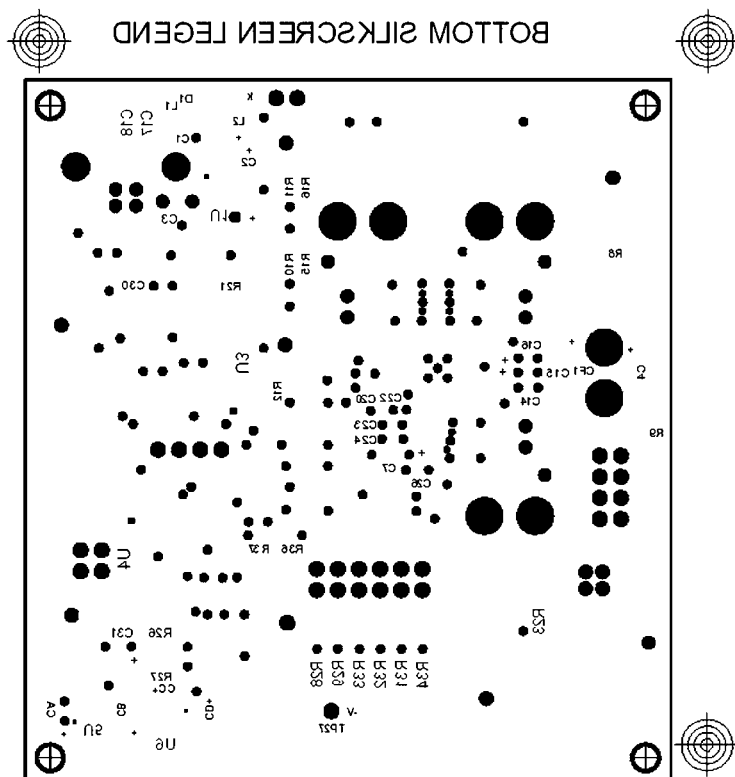
Bottom (Solider Side) Layer 4



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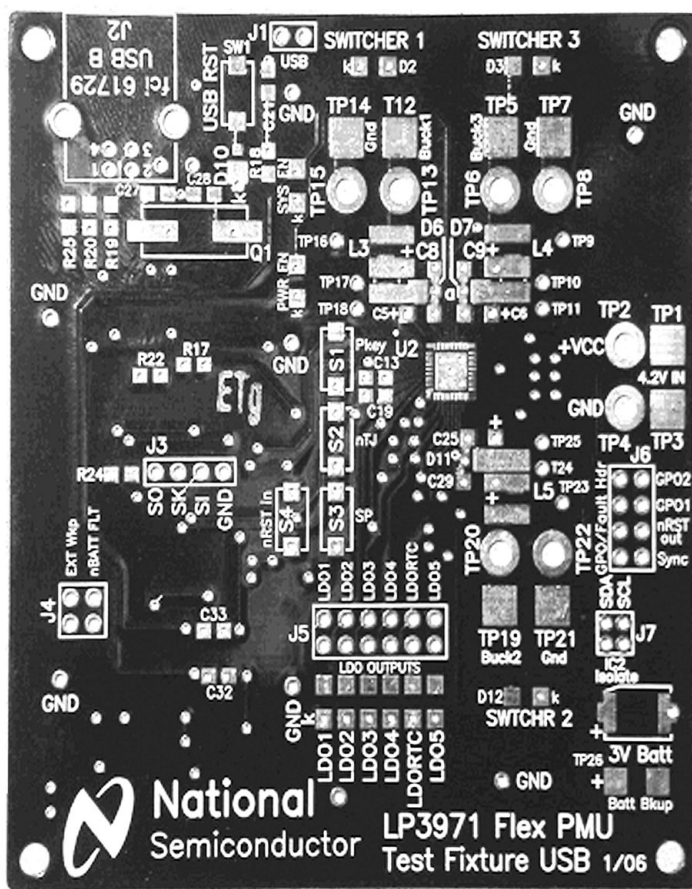
## Bottom Silkscreen

BOTTOM SILKSCREEN LEGEND



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## Bare Board/Component Locations



30018209



## Notes

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