



# High Current Quad Output Regulator for TFT LCD Panels

September 2003

## FEATURES

- 4 Integrated Switches: 2.4A Buck, 2.6A Boost, 0.35A Boost, 0.35A Inverter (Guaranteed Minimum Current Limit)
- Fixed Frequency, Low Noise Outputs
- Soft Start for all Outputs
- Externally Programmable  $V_{ON}$  Delay
- Integrated Schottky Diode for  $V_{ON}$  Output
- PGOOD Pin for  $AV_{DD}$  Output Disconnect
- 4.5V to 22V Input Voltage Range
- PanelProtect™ Circuitry Disables  $V_{ON}$  Upon Fault
- Thermally Enhanced 28-Lead TSSOP

## APPLICATIONS

- Large TFT-LCD Desktop Monitor Displays
- Flat Panel Televisions

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PanelProtect is a trademark of Linear Technology Corporation.

## DESCRIPTION

The LT®1943 quad output adjustable switching regulator provides power for large TFT LCD panels. The device, housed in a low profile 28 pin thermally enhanced TSSOP package, can generate a 3.3V or 5V logic supply along with the triple output supply required for the TFT LCD panel. Operating from an input range of 4.5V to 22V, a step-down regulator provides a low voltage output  $V_{LOGIC}$  with up to 2A current. A high-power step-up converter, a lower-power step-up converter and an inverting converter provide the three independent output voltages  $AV_{DD}$ ,  $V_{ON}$  and  $V_{OFF}$  required by the LCD panel. A high-side PNP provides delayed turn-on of the  $V_{ON}$  signal and can handle up to 30mA. Protection circuitry ensures  $V_{ON}$  is disabled if any of the four outputs are more than 10% below normal voltage.

All switchers are synchronized to the internal 1.2MHz clock, allowing the use of low profile inductors and ceramic capacitors throughout. A current mode architecture provides excellent transient response. For best flexibility, all outputs are adjustable. Soft-start is included in all four channels. A PGOOD pin can drive an optional PMOS pass device to provide output disconnect for the  $AV_{DD}$  output.

## TYPICAL APPLICATION

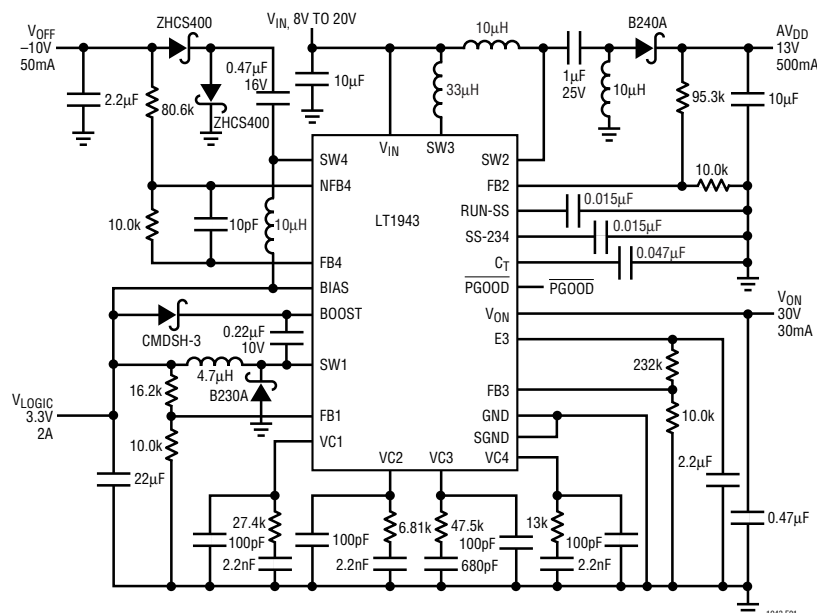
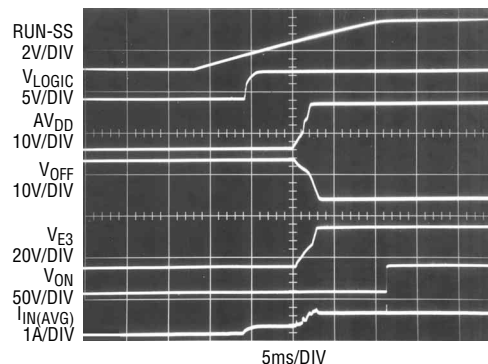


Figure 1. Quad Output TFT-LCD Power Supply

### Startup Waveforms

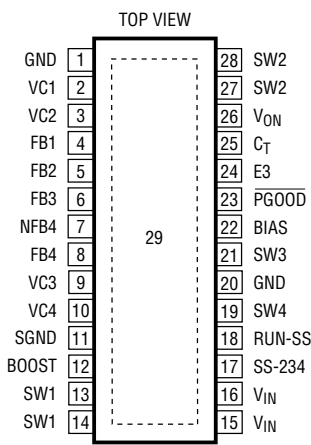


## ABSOLUTE MAXIMUM RATINGS

(Note 1)

|                                            |                |
|--------------------------------------------|----------------|
| $V_{IN}$ Voltage .....                     | 25V            |
| BOOST Voltage .....                        | 36V            |
| BOOST Voltage Above SW1 .....              | 25V            |
| BIAS Pin Voltage .....                     | 18V            |
| SW2, SW4 Pin Voltages .....                | 40V            |
| SW3 Voltage .....                          | 36V            |
| FB1, FB2, FB3, FB4 Voltages .....          | 4V             |
| NFB4 Voltage .....                         | +6V, -0.6V     |
| VC1, VC2, VC3, VC4 Pin Voltages .....      | 6V             |
| RUN-SS, SS-234 Pin Voltages .....          | 6V             |
| PGOOD Pin Voltage .....                    | 36V            |
| E3 Pin Voltage .....                       | 36V            |
| $V_{ON}$ Voltage .....                     | 36V            |
| $C_T$ Pin Voltage .....                    | 6V             |
| Junction Temperature .....                 | 125°C          |
| Operating Temperature Range (Note 2) ...   | -40°C to 85°C  |
| Storage Temperature Range .....            | -65°C to 150°C |
| Lead Temperature (Soldering, 10 sec) ..... | 300°C          |

## PACKAGE/ORDER INFORMATION

|                                                                                                                                                                                                                                                                                                                                                                       |                   |  |
|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------|--|
|  <p>TOP VIEW</p> <p>FE PACKAGE<br/>28-LEAD PLASTIC TSSOP<br/>EXPOSED PAD (PIN 29) IS GROUND<br/>(MUST BE SOLDERED TO PCB)</p> <p><math>T_{JMAX} = 150^{\circ}\text{C}</math>, <math>\theta_{JA} = 25^{\circ}\text{C/W}</math>, <math>\theta_{JC} = 7.5^{\circ}\text{C/W}</math></p> | ORDER PART NUMBER |  |
|                                                                                                                                                                                                                                                                                                                                                                       | LT1943EFE         |  |
|                                                                                                                                                                                                                                                                                                                                                                       | FE PART MARKING   |  |
|                                                                                                                                                                                                                                                                                                                                                                       | 1943EFE           |  |

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  $T_A = 25^{\circ}\text{C}$ .  $V_{IN} = 12\text{V}$ , RUN-SS, SS-234 = 2.5V unless otherwise noted.

| PARAMETER                                 | CONDITIONS                            | MIN        | TYP      | MAX          | UNITS               |
|-------------------------------------------|---------------------------------------|------------|----------|--------------|---------------------|
| Minimum Input Voltage                     | ●                                     |            |          | 4.5          | V                   |
| Maximum Input Voltage                     |                                       |            |          | 22           | V                   |
| Quiescent Current                         | Not Switching<br>RUN-SS = SS-234 = 0V |            | 10<br>35 | 14<br>45     | mA<br>$\mu\text{A}$ |
| RUN-SS, SS-234 Pin Current                | RUN-SS, SS-234 = 0.4V                 |            | 1.7      |              | $\mu\text{A}$       |
| RUN-SS, SS-234 Threshold                  |                                       |            | 0.8      |              | V                   |
| BIAS Pin Voltage to Begin SS-234 Charge   | ●                                     | 2.4        | 2.8      | 3.15         | V                   |
| BIAS Pin Current                          | BIAS = 3.1V, All Switches Off         |            | 10.5     | 15           | mA                  |
| FB Threshold Offset to Begin $C_T$ Charge | (Note 3)                              | 90         | 125      | 160          | mV                  |
| $C_T$ Pin Current Source                  | All FB Pins = 1.5V                    | 16         | 20       | 25           | $\mu\text{A}$       |
| $C_T$ Threshold to Power $V_{ON}$         | All FB Pins = 1.5V                    | 1.0        | 1.1      | 1.2          | V                   |
| $V_{ON}$ Switch Drop                      | $V_{ON}$ Current = 30mA               |            | 180      | 240          | mV                  |
| Maximum $V_{ON}$ Current                  | $V_{E3} = 30\text{V}$                 | ● 30       | 60       |              | mA                  |
| PGOOD Threshold Offset                    |                                       | 90         | 125      | 160          | mV                  |
| PGOOD Pin Leakage                         | $V_{PGOOD} = 36\text{V}$              |            |          | 1            | $\mu\text{A}$       |
| Master Oscillator Frequency               | ●                                     | 1.1<br>1.0 | 1.2      | 1.35<br>1.46 | MHz<br>MHz          |
| Foldback Switching Frequency              | All FB Pins = 0V                      |            | 250      |              | kHz                 |
| Frequency Shift Threshold on FB           | $\Delta 200\text{kHz}$                |            | 0.5      |              | V                   |

## ELECTRICAL CHARACTERISTICS

The ● denotes the specifications which apply over the full operating temperature range, otherwise specifications are at  $T_A = 25^\circ\text{C}$ .  $V_{IN} = 12\text{V}$ , RUN-SS, SS-234 = 2.5V unless otherwise noted.

| PARAMETER                           | CONDITIONS                          |   | MIN          | TYP  | MAX          | UNITS            |
|-------------------------------------|-------------------------------------|---|--------------|------|--------------|------------------|
| <b>SWITCH 1 (2.4A BUCK)</b>         |                                     |   |              |      |              |                  |
| FB1 Voltage                         |                                     | ● | 1.23<br>1.22 | 1.25 | 1.27<br>1.27 | V<br>V           |
| FB1 Voltage Line Regulation         | $4.5\text{V} < V_{IN} < 22\text{V}$ |   |              | 0.01 | 0.03         | %/V              |
| FB1 Pin Bias Current                | (Note 4)                            | ● |              | 100  | 600          | nA               |
| Error Amplifier 1 Voltage Gain      |                                     |   |              | 200  |              | V/V              |
| Error Amplifier 1 Transconductance  | $\Delta I = 5\mu\text{A}$           |   |              | 450  |              | $\mu\text{mhos}$ |
| Switch 1 Current Limit              | Duty Cycle = 35%                    | ● | 2.4          | 3.2  | 4.3          | A                |
| Switch 1 $V_{CESAT}$                | $I_{SW} = 2\text{A}$                |   |              | 310  | 470          | mV               |
| Switch 1 Leakage Current            | FB1 = 1.5V                          |   |              | 0.1  | 10           | $\mu\text{A}$    |
| Minimum BOOST Voltage Above SW1 Pin | $I_{SW} = 1.5\text{A}$              |   |              | 1.8  | 2.5          | V                |
| BOOST Pin Current                   | $I_{SW} = 1.5\text{A}$              |   |              | 30   | 50           | mA               |
| Maximum Duty Cycle (SW1)            |                                     | ● | 82           | 92   |              | %                |
| <b>SWITCH 2 (2.6A BOOST)</b>        |                                     |   |              |      |              |                  |
| FB2 Voltage                         |                                     | ● | 1.23<br>1.22 | 1.25 | 1.27<br>1.27 | V<br>V           |
| FB2 Voltage Line Regulation         | $4.5\text{V} < V_{IN} < 22\text{V}$ |   |              | 0.01 | 0.03         | %/V              |
| FB2 Pin Bias Current                | (Note 4)                            | ● |              | 220  | 1000         | nA               |
| Error Amplifier 2 Voltage Gain      |                                     |   |              | 200  |              | V/V              |
| Error Amplifier 2 Transconductance  | $\Delta I = 5\mu\text{A}$           |   |              | 450  |              | $\mu\text{mhos}$ |
| Switch 2 Current Limit              |                                     | ● | 2.6          | 3.8  | 4.9          | A                |
| Switch 2 $V_{CESAT}$                | $I_{SW2} = 2\text{A}$               |   |              | 360  | 540          | mV               |
| Switch 2 Leakage Current            | FB2 = 1.5V                          |   |              | 0.1  | 1            | $\mu\text{A}$    |
| BIAS Pin Current                    | $I_{SW2} = 2\text{A}$               |   |              | 45   |              | mA               |
| Maximum Duty Cycle (SW2)            |                                     | ● | 85           | 92   |              | %                |
| <b>SWITCH 3 (350mA BOOST)</b>       |                                     |   |              |      |              |                  |
| FB3 Voltage                         |                                     | ● | 1.23<br>1.22 | 1.25 | 1.27<br>1.27 | V<br>V           |
| FB3 Voltage Line Regulation         | $4.5\text{V} < V_{IN} < 22\text{V}$ |   |              | 0.01 | 0.03         | %/V              |
| FB3 Pin Bias Current                | (Note 4)                            | ● |              | 100  | 600          | nA               |
| Error Amplifier 3 Voltage Gain      |                                     |   |              | 200  |              | V/V              |
| Error Amplifier 3 Transconductance  | $\Delta I = 5\mu\text{A}$           |   |              | 450  |              | $\mu\text{mhos}$ |
| Switch 3 Current Limit              |                                     | ● | 0.35         | 0.5  | 0.7          | A                |
| Switch 3 $V_{CESAT}$                | $I_{SW3} = 0.2\text{A}$             |   |              | 180  | 280          | mV               |
| Switch 3 Leakage Current            | FB3 = 1.5V                          |   |              | 0.1  | 1            | $\mu\text{A}$    |
| BIAS Pin Current                    | $I_{SW3} = 0.2\text{A}$             |   |              | 14   |              | mA               |
| Maximum Duty Cycle (SW3)            |                                     | ● | 84<br>83     | 88   |              | %<br>%           |
| Schottky Diode Drop                 | $I = 170\text{mA}$                  |   |              | 700  |              | mV               |

**ELECTRICAL CHARACTERISTICS**

The ● denotes the specifications which apply over the full operating temperature range, otherwise specifications are at  $T_A = 25^\circ\text{C}$ . RUN-SS, SS-234 = 2.5V unless otherwise noted.

| PARAMETER                                           | CONDITIONS                                 | MIN              | TYP   | MAX            | UNITS            |
|-----------------------------------------------------|--------------------------------------------|------------------|-------|----------------|------------------|
| <b>SWITCH 4 (350mA INVERTER)</b>                    |                                            |                  |       |                |                  |
| FB4 Voltage                                         |                                            | ● 1.23<br>1.22   | 1.25  | 1.27<br>1.27   | V<br>V           |
| FB4 Voltage Line Regulation                         | $4.5\text{V} < V_{\text{IN}} < 22\text{V}$ |                  | 0.01  | 0.03           | %/V              |
| FB4 Pin Bias Current                                | (Note 4)                                   | ●                | 100   | 600            | nA               |
| NFB4 Voltage ( $V_{\text{FB4}} - V_{\text{NFB4}}$ ) |                                            | ● 1.215<br>1.205 | 1.245 | 1.275<br>1.275 | V<br>V           |
| NFB4 Voltage Line Regulation                        | $4.5\text{V} < V_{\text{IN}} < 22\text{V}$ |                  | 0.01  | 0.03           | %/V              |
| NFB4 Pin Bias Current                               | (Note 5)                                   |                  | 100   | 600            | nA               |
| Error Amplifier 4 Voltage Gain                      |                                            |                  | 200   |                | V/V              |
| Error Amplifier 4 Transconductance                  | $\Delta I = 5\mu\text{A}$                  |                  | 450   |                | $\mu\text{mhos}$ |
| Switch 4 Current Limit                              |                                            | ● 0.35           | 0.5   | 0.7            | A                |
| Switch 4 $V_{\text{CESAT}}$                         | $I_{\text{SW4}} = 0.3\text{A}$             |                  | 260   | 390            | mV               |
| Switch 4 Leakage Current                            |                                            |                  | 0.1   | 1              | $\mu\text{A}$    |
| BIAS Pin Current due to SW4                         | $I_{\text{SW4}} = 0.3\text{A}$             |                  | 15    |                | mA               |
| Maximum Duty Cycle (SW4)                            |                                            | ● 84<br>83       | 88    |                | %<br>%           |

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

**Note 2:** The LT1943E is guaranteed to meet performance specifications from  $0^\circ\text{C}$  to  $70^\circ\text{C}$ . Specifications over the  $-40^\circ\text{C}$  to  $85^\circ\text{C}$  operating temperature range are assured by design, characterization, and correlation with statistical process controls.

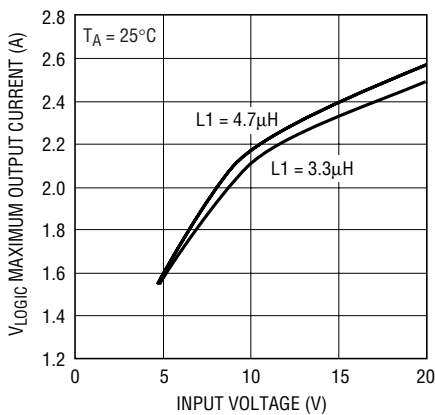
**Note 3:** The  $C_T$  pin is held low until FB1, FB2, FB3 and FB4 all ramp above the FB threshold offset.

**Note 4:** Current flows into FB1, FB2, FB3 and FB4 pins.

**Note 5:** Current flows out of NFB4 pin.

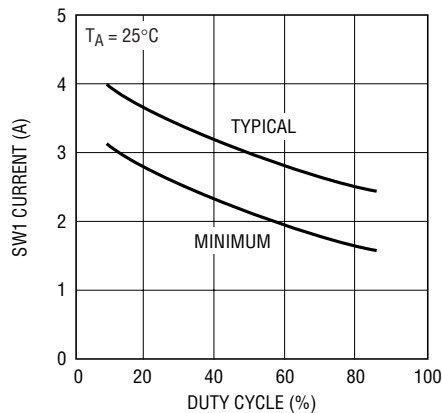
**TYPICAL PERFORMANCE CHARACTERISTICS**

**Maximum Output Current for  $V_{\text{LOGIC}}$**



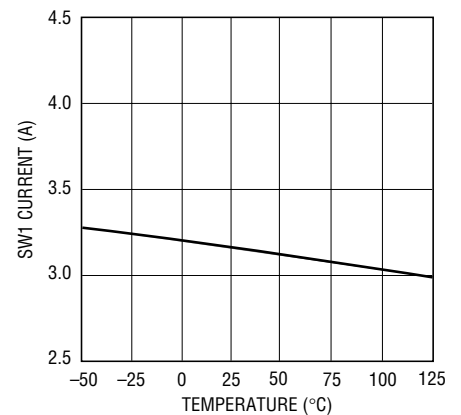
1943 G01

**SW1 Current Limit vs Duty Cycle**



1943 G02

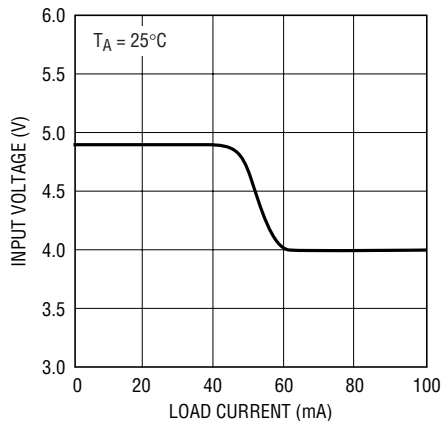
**SW1 Current Limit**



1943 G03

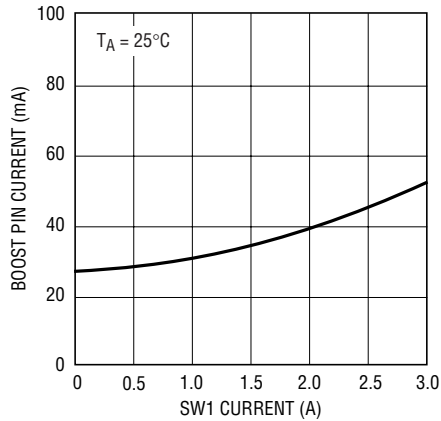
# TYPICAL PERFORMANCE CHARACTERISTICS

**MINIMUM Input Voltage to Start,  
 $V_{OUT} = 3.3V$**



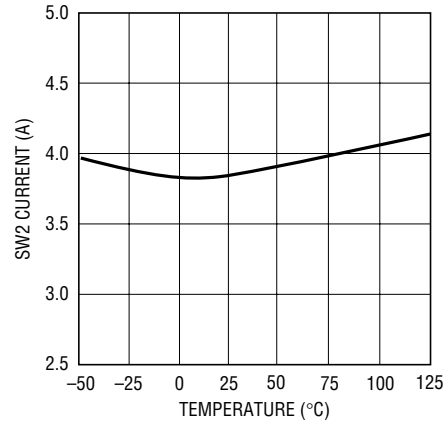
1943 G04

**BOOST Pin Current**



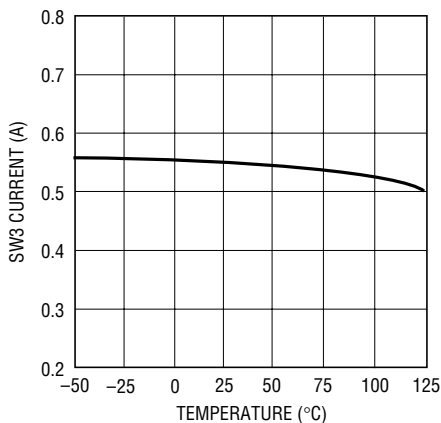
1943 G05

**SW2 Current Limit**



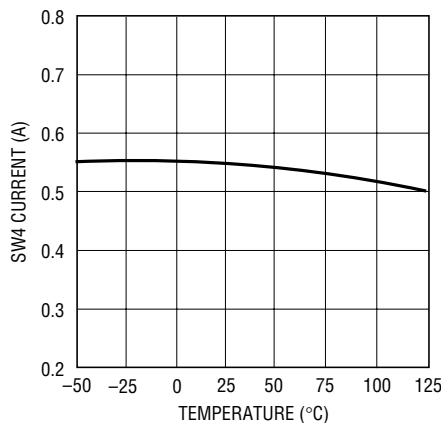
1943 G06

**SW3 Current Limit**



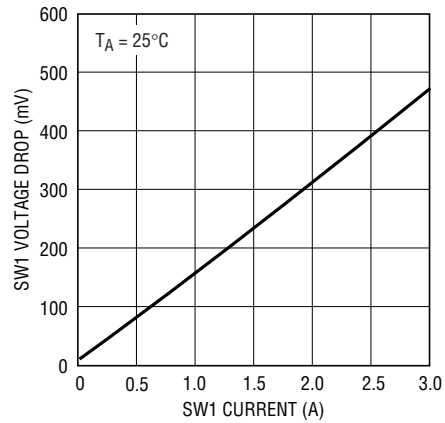
1943 G07

**SW4 Current Limit**



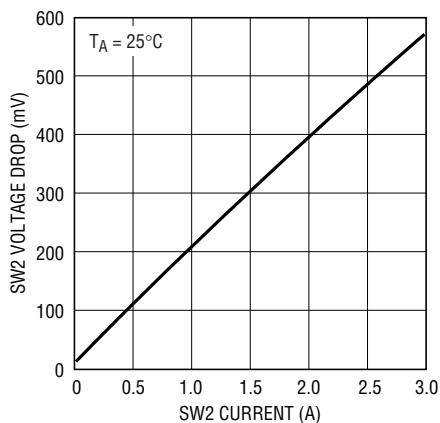
1943 G08

**SW1  $V_{CESAT}$**



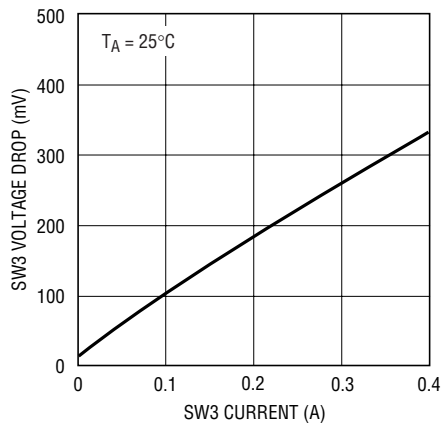
1943 G09

**SW2  $V_{CESAT}$**



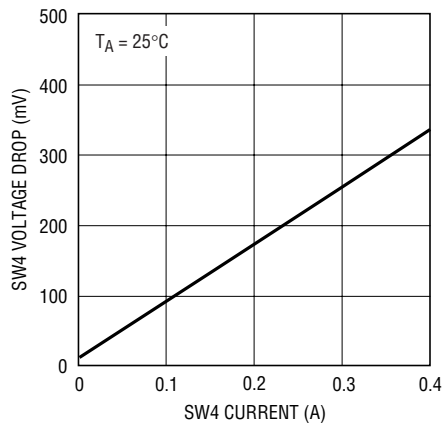
1943 G10

**SW3  $V_{CESAT}$**



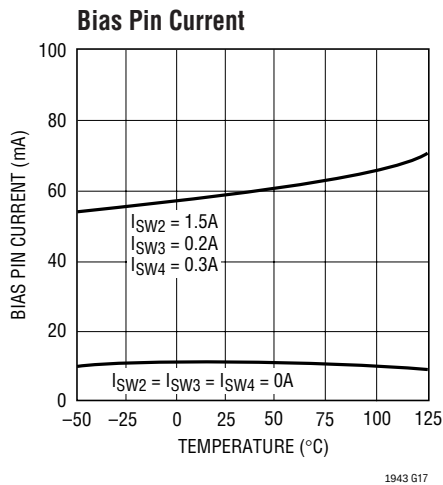
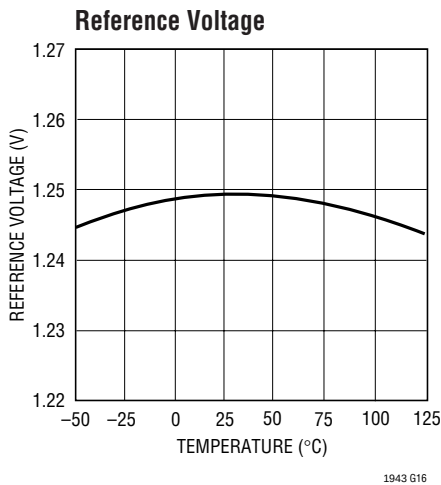
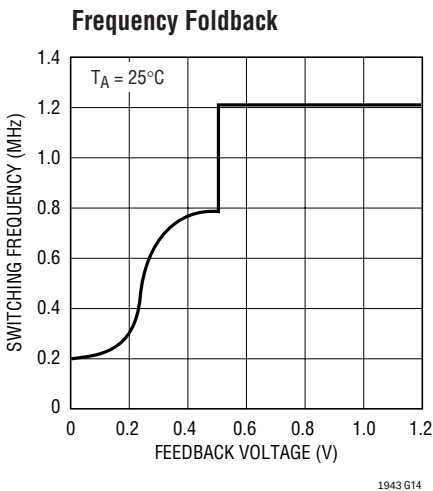
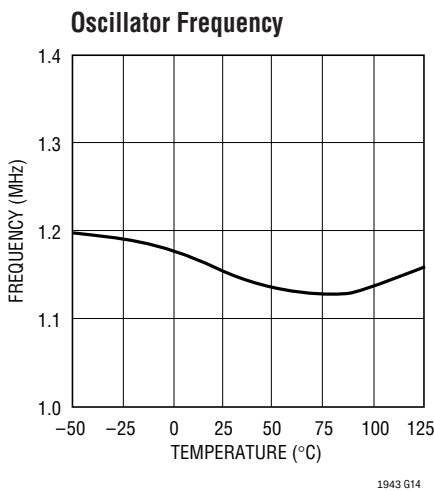
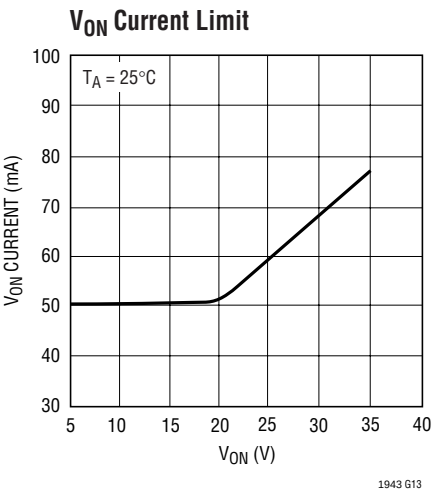
1943 G11

**SW4  $V_{CESAT}$**



1943 G12

TYPICAL PERFORMANCE CHARACTERISTICS



## PIN FUNCTIONS

**GND (Pins 1, 20, Exposed Pad Pin 29):** Ground. Tie both GND pins and the exposed pad directly to local ground plane. The ground metal to the exposed pad should be as wide as possible for better heat dissipation. Multiple vias (to ground plane under the ground backplane) placed close to the exposed pad can further aid in reducing thermal resistance.

**VC1 (Pin 2):** Switching Regulator 1 Error Amplifier Compensation. Connect a resistor/capacitor network in series with this pin.

**VC2 (Pin 3):** Error Amplifier Compensation for Switcher 2. Connect a resistor/capacitor network in series with this pin.

**FB1 (Pin 4):** Switching Regulator 1 Feedback. Tie the resistor divider tap to this pin and set  $V_{\text{LOGIC}}$  according to  $V_{\text{LOGIC}} = 1.25 \cdot (1 + R_2/R_1)$ . Reference designators refer to Figure 2.

**FB2 (Pin 5):** Feedback for Switch 2. Tie the resistor divider tap to this pin and set  $AV_{\text{DD}}$  according to  $AV_{\text{DD}} = 1.25 \cdot (1 + R_6/R_5)$ .

**FB3 (Pin 6):** Switching Regulator 3 Feedback. Tie the resistor divider tap to this pin and set  $V_{\text{ON}}$  according to  $V_{\text{ON}} = 1.25 \cdot (1 + R_9/R_8) - 150\text{mV}$ .

**NFB4 (Pin 7):** Switching Regulator 4 Negative Feedback. Switcher 4 can be used to generate a positive or negative output. When regulating a negative output, tie the resistor divider tap to this pin. Negative output voltage can be set by the equation  $V_{\text{OFF}} = -1.25 \cdot (R_3/R_4)$  with  $R_4$  set to 10k. Tie the NFB4 pin to FB4 for positive output voltages.

**FB4 (Pin 8):** Feedback for Switch 4. When generating a positive voltage from switch 4, tie the resistor divider tap to this pin. When generating a negative voltage, tie a 10k resistor between FB4 and NFB4 ( $R_4$ ).

**VC3 (Pin 9):** Switching Regulator 3 Error Amplifier Compensation. Connect a resistor/capacitor network in series with this pin.

**VC4 (Pin 10):** Switching Regulator 4 Error Amplifier Compensation. Connect a resistor/capacitor network in series with this pin.

**SGND (Pin 11):** Signal Ground. Return ground trace from the FB resistor networks and  $V_{\text{C}}$  pin compensation components directly to this pin and then tie to ground.

**BOOST (Pin 12):** The BOOST pin is used to provide a drive voltage, higher than  $V_{\text{IN}}$ , to the switch 1 drive circuit.

**SW1 (Pins 13, 14):** The SW1 pins are the emitter of the internal NPN bipolar power transistor for switching regulator 1. These pins must be tied together for proper operation. Connect these pins to the inductor, catch diode and boost capacitor.

**$V_{\text{IN}}$  (Pins 15, 16):** The  $V_{\text{IN}}$  pins supply current to the LT1943's internal regulator and to the internal power transistor for switch 1. These pins must be tied together and locally bypassed.

**SS-234 (Pin 17):** This is the soft-start pin for switching regulators 2, 3 and 4. Place a soft-start capacitor here to limit start-up inrush current and output voltage ramp rate. When the BIAS pin reaches 2.8V, a 1.7 $\mu\text{A}$  current source begins charging the capacitor. When the capacitor voltage reaches 0.8V, switches 2, 3 and 4 turn on and begin switching. For slower start-up, use a larger capacitor. When this pin is pulled to ground, switches 2, 3 and 4 are disabled. For complete shutdown, tie RUN-SS to ground.

**RUN-SS (Pin 18):** This is the soft-start pin for switching regulator 1. Place a soft-start capacitor here to limit start-up inrush current and output voltage ramp rate. When power is applied to the  $V_{\text{IN}}$  pin, a 1.7 $\mu\text{A}$  current source charges the capacitor. When the voltage at this pin reaches 0.8V, switch 1 turns on and begins switching. For slower start-up, use a larger capacitor. For complete shutdown, tie RUN-SS to ground.

**SW4 (Pin 19):** This is the collector of the internal NPN bipolar power transistor for switching regulator 4. Minimize metal trace area at this pin to keep EMI down.

## PIN FUNCTIONS

**SW3 (Pin 21):** This is the collector of the internal NPN bipolar power transistor for switching regulator 3. Minimize metal trace area at this pin to keep EMI down.

**BIAS (Pin 22):** The BIAS pin is used to improve efficiency when operating at higher input voltages. Connecting this pin to the output of switching regulator 1 forces most of the internal circuitry to draw its operating current from  $V_{\text{LOGIC}}$  rather than  $V_{\text{IN}}$ . Switches 2, 3 and 4 drivers are supplied by BIAS and will not switch until this pin reaches approximately 2.8V. BIAS must be tied to  $V_{\text{LOGIC}}$ .

**PGOOD (Pin 23):** Power Good Comparator Output. This is the open collector output of the power good comparator and can be used in conjunction with an external P-Channel MOSFET to provide output disconnect for  $AV_{\text{DD}}$ . When switcher 2's output reaches approximately 90% of its programmed voltage,  $\overline{\text{PGOOD}}$  will be pulled to ground. This will pull down on the gate of the MOSFET, connecting  $AV_{\text{DD}}$ . A 100k pull-up resistor between the source and drain of the P-channel MOSFET keeps it off when switcher 2's output is low.

**E3 (Pin 24):** This is switching regulator 3's output and the emitter of the output disconnect PNP. Tie the output capacitor and resistor divider here.

**$C_T$  (Pin 25):** Timing Capacitor Pin. This is the input to the  $V_{\text{ON}}$  timer and programs the time delay from all four feedback pins reaching 1.125V to  $V_{\text{ON}}$  turning on. The  $C_T$  capacitor value can be set using the equation  $C = (20\mu\text{A} \cdot t_{\text{DELAY}})/1.1\text{V}$ .

**$V_{\text{ON}}$  (Pin 26):** This is the delayed output for switching regulator 3.  $V_{\text{ON}}$  reaches its programmed voltage after the internal  $C_T$  timer times out. Protection circuitry ensures  $V_{\text{ON}}$  is disabled if any of the four outputs are more than 10% below normal voltage.

**SW2 (Pins 27, 28):** The SW2 pins are the collector of the internal NPN bipolar power transistor for switching regulator 2. These pins must be tied together. Minimize trace area at these pins to keep EMI down.



# BLOCK DIAGRAM

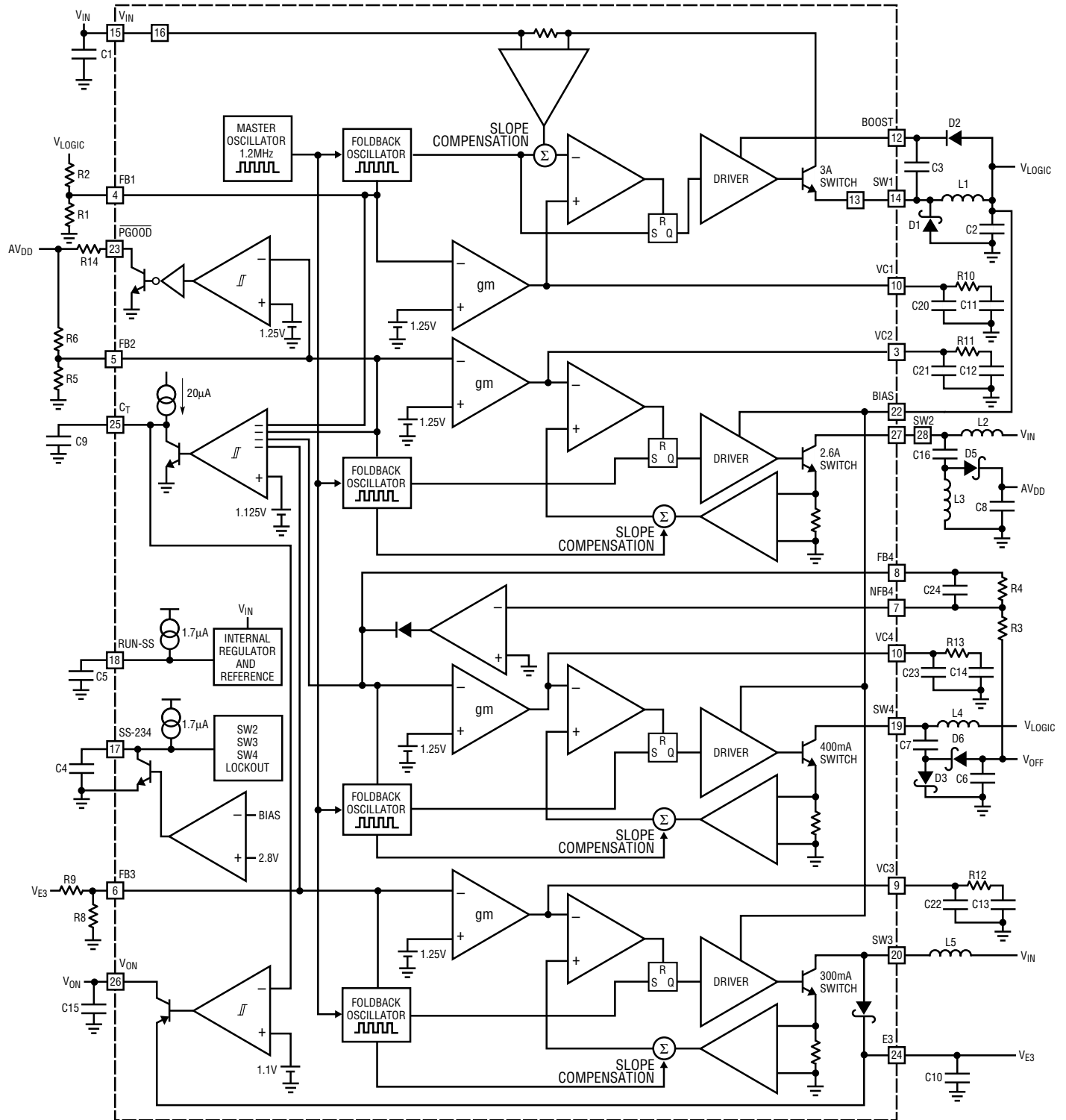


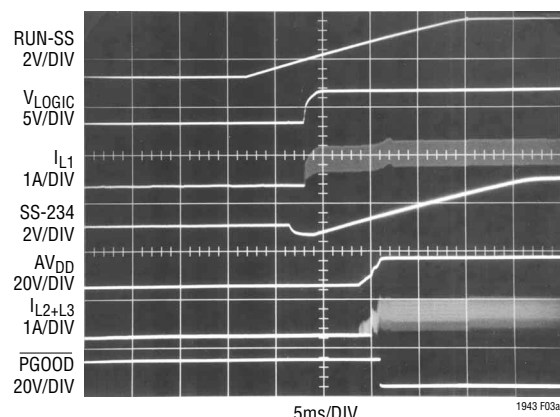
Figure 2.

## OPERATION

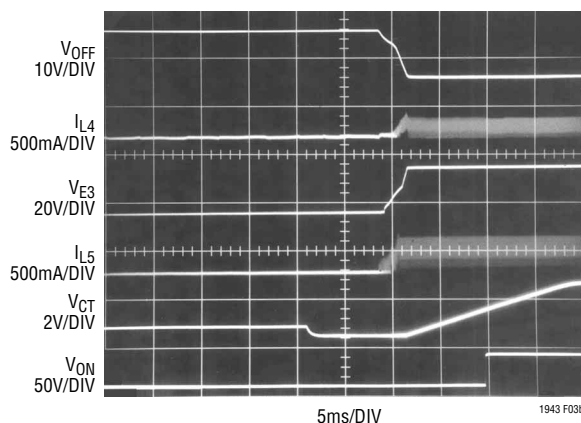
The LT1943 is a highly integrated power supply IC containing four separate switching regulators. All four switchers have their own oscillator with frequency foldback and use current mode control. Switching regulator 1 consists of a step-down regulator with a current limit of 2.4A. Switching regulator 2 is a boost regulator with a current limit of 2.6A and switchers 3 and 4 are 0.35A boost regulators. Switching regulator 4 has two feedback pins (FB4 and NFB4) and can directly regulate positive or negative output voltages.

When power is applied to  $V_{IN}$ , the RUN-SS pin starts charging and when its voltage reaches 0.8V, switcher 1 is enabled. (See Figure 2) The RUN-SS pin is used for soft-start and limits the ramp-rate for  $V_{LOGIC}$ . Using a larger capacitor at the RUN-SS pin will cause  $V_{LOGIC}$  to start more slowly. Switching regulators 2, 3 and 4 are driven by the BIAS pin which must be connected to  $V_{LOGIC}$ .  $V_{LOGIC}$  is the first to come up and when it reaches 2.8V, the SS-234 pin will begin charging to enable switches 2, 3 and 4.  $AV_{DD}$  and  $V_{OFF}$  will then begin rising and their ramp rate is determined by the capacitor tied to the SS-234 pin. When  $AV_{DD}$  reaches approximately 90% of its programmed voltage, the  $\overline{PGOOD}$  pin will be pulled low. When all outputs reach 90% of their programmed voltages, the  $C_T$  timer will trigger and a 20 $\mu$ A current source begins to charge the  $C_T$  pin. When the  $C_T$  pin reaches 1.1V, the output disconnect PNP turns on, connecting  $V_{ON}$ . In the event of any of the 4 outputs dropping below 10% of its normal voltage, PanelProtect circuitry pulls the  $C_T$  pin to ground, disabling  $V_{ON}$ .

When needed, the  $\overline{PGOOD}$  pin can be used to drive the gate of a P-channel MOSFET that functions as output disconnect for  $AV_{DD}$ . For complete shutdown, the RUN-SS pin must be pulled to ground.



(3a)



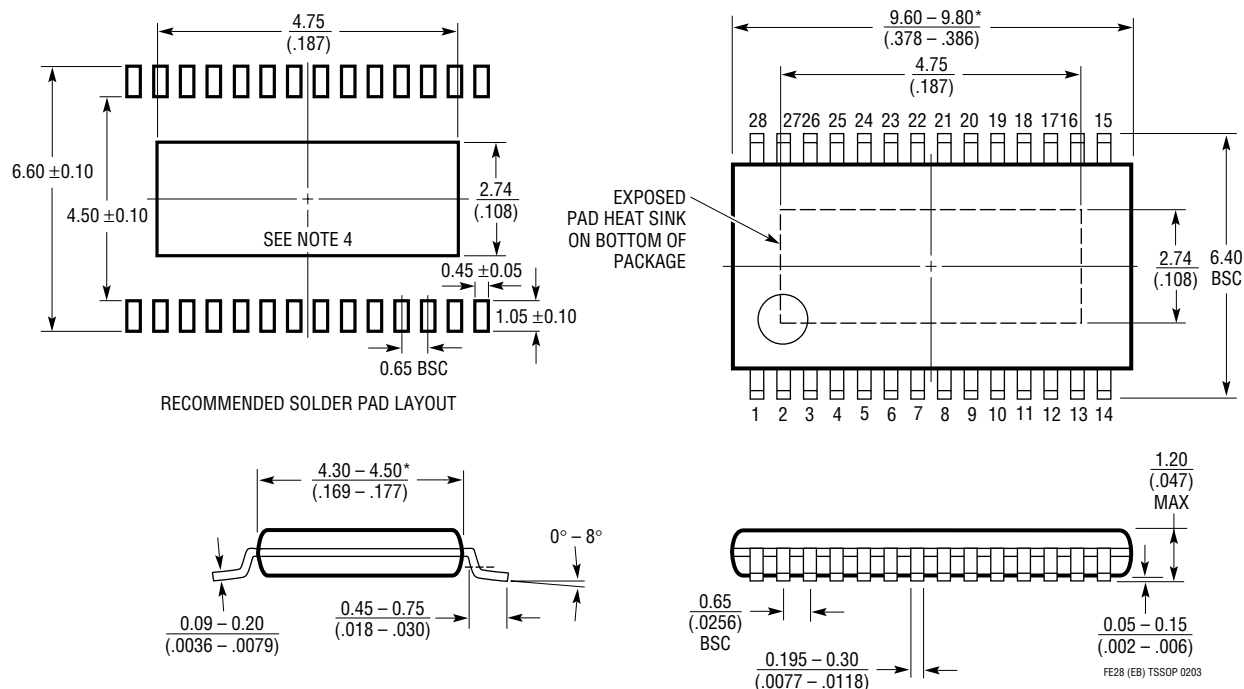
(3b)

**Figure 3. LT1943 Power-Up Sequence. (Traces From Both Photos are Synchronized to the Same Trigger)**

## PACKAGE DESCRIPTION

**FE Package**  
**28-Lead Plastic TSSOP (4.4mm)**  
 (Reference LTC DWG # 05-08-1663)

**Exposed Pad Variation EB**



**NOTE:**

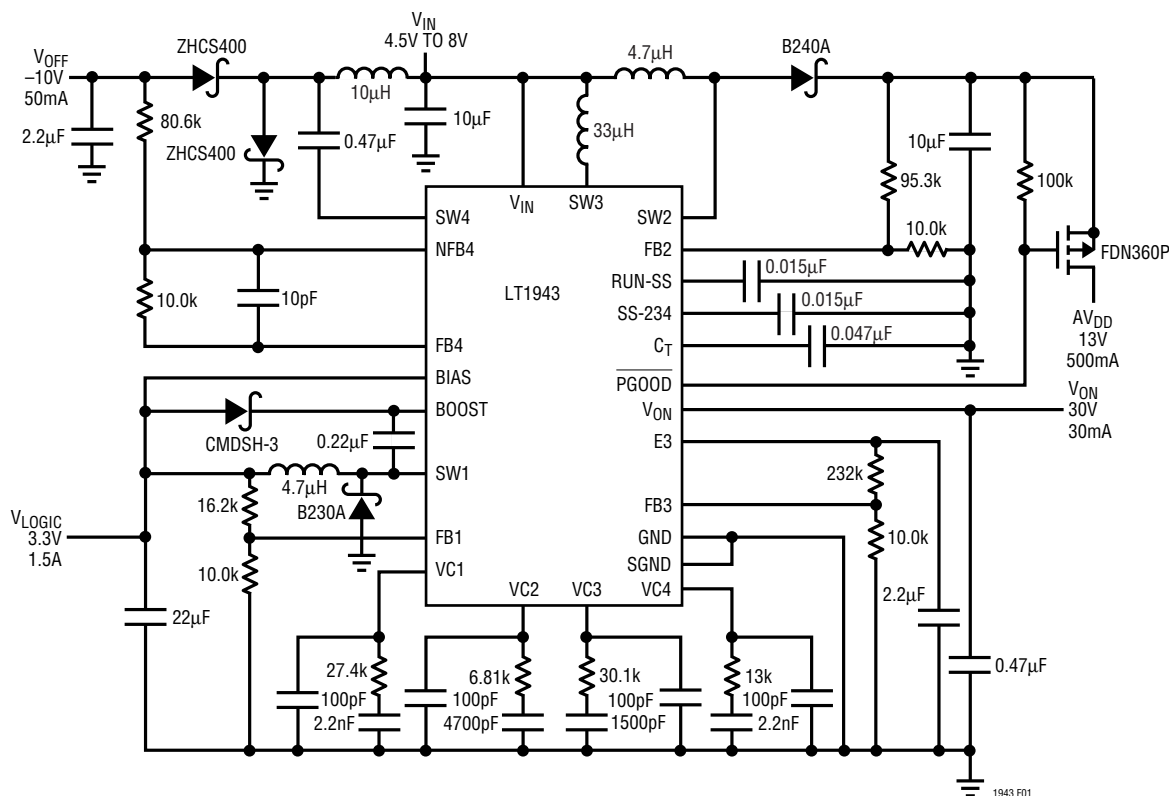
1. CONTROLLING DIMENSION: MILLIMETERS
2. DIMENSIONS ARE IN  $\frac{\text{MILLIMETERS}}{\text{INCHES}}$
3. DRAWING NOT TO SCALE

4. RECOMMENDED MINIMUM PCB METAL SIZE FOR EXPOSED PAD ATTACHMENT

\*DIMENSIONS DO NOT INCLUDE MOLD FLASH. MOLD FLASH SHALL NOT EXCEED  $0.150\text{mm}$  ( $.006$ ) PER SIDE

## TYPICAL APPLICATION

## 5V Input, Quad Output TFT-LCD Power Supply



## RELATED PARTS

| PART NUMBER     | DESCRIPTION                                                                                                                      | COMMENTS                                                                                                   |
|-----------------|----------------------------------------------------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------|
| LT1615/LT1615-1 | 300mA/80mA ( $I_{SW}$ ), Constant Off-Time, High Efficiency Step-Up DC/DC Converters                                             | $V_{IN}$ : 1.2V to 15V, $V_{OUT(MAX)}$ : 34V, $I_Q$ : 20 $\mu$ A, $I_{SD}$ : <1 $\mu$ A, ThinSOT™ Package  |
| LT1940          | Dual Output 1.4A ( $I_{OUT}$ ), Constant 1.1MHz, High Efficiency Step-Down DC/DC Converter                                       | $V_{IN}$ : 3V to 25V, $V_{OUT(MIN)}$ : 1.2V, $I_Q$ : 2.5mA, $I_{SD}$ : <1 $\mu$ A, TSSOP-16E Package       |
| LT1944/LT1944-1 | Dual Output 350mA ( $I_{SW}$ ), Constant Off-Time, High Efficiency Step-Up DC/DC Converter                                       | $V_{IN}$ : 1.2V to 15V, $V_{OUT(MAX)}$ : 34V, $I_Q$ : 20 $\mu$ A, $I_{SD}$ : <1 $\mu$ A, MS Package        |
| LT1945          | Dual Output, Pos/Neg, 350mA ( $I_{SW}$ ), Constant Off-Time, High Efficiency Step-Up DC/DC Converter                             | $V_{IN}$ : 1.2V to 15V, $V_{OUT(MAX)}$ : $\pm$ 34V, $I_Q$ : 20 $\mu$ A, $I_{SD}$ : <1 $\mu$ A, MS Package  |
| LT1946/LT1946A  | 1.5mA ( $I_{SW}$ ), 1.2MHz/2.7MHz, High Efficiency Step-Up DC/DC Converter                                                       | $V_{IN}$ : 2.75V to 16V, $V_{OUT(MAX)}$ : 34V, $I_Q$ : 20 $\mu$ A, $I_{SD}$ : <1 $\mu$ A, MS Package       |
| LT1947          | 1.1A, 3MHz, TFT-LCD Triple Output Switching Regulator                                                                            | $V_{IN}$ : 2.7V to 8V, $V_{OUT(MAX)}$ : 34V, $I_Q$ : 9.5mA, $I_{SD}$ : <1 $\mu$ A, MS Package              |
| LT3464          | 85mA ( $I_{SW}$ ), Constant Off-Time, High Efficiency Step-Up DC/DC Converter with Integrated Schottky and Output Disconnect PNP | $V_{IN}$ : 2.3V to 10V, $V_{OUT(MAX)}$ : 34V, $I_Q$ : 25 $\mu$ A, $I_{SD}$ : <0.5 $\mu$ A, ThinSOT Package |

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