

**NOT RECOMMENDED FOR NEW DESIGNS**

Contact Linear Technology for Potential Replacement

## FEATURES

- Complete Solution Under 1.2mm
- Develops Three Outputs from a 3.3V or 5V Supply
- Externally Programmable  $V_{ON}$  Delay
- Fixed Frequency Low Noise Outputs
- All Ceramic Capacitors
- Operates at 3MHz Switching Frequency
- Fast Transient Response
- Few External Components Required
- 2.6V to 6V Input Range
- Tiny 8-Lead MSOP Package

## APPLICATIONS

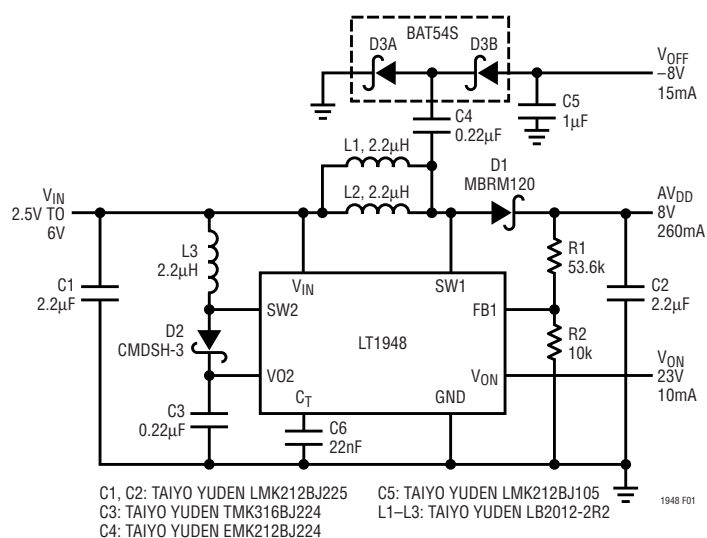
- TFT-LCD Notebook Display Panels
- TFT-LCD Desktop Monitor Display Panels
- Digital Cameras
- Handheld Computers

## DESCRIPTION

The LT<sup>®</sup>1948 is a highly integrated multiple output DC/DC converter designed for use in TFT-LCD panels. The device contains two independent switching regulators: the main regulator has an adjustable output voltage with an internal 1.1A switch that can generate a boosted voltage as high as 30V while the second regulator generates 23V at up to 10mA for positive bias. A simple level-shift charge pump off the main switch node generates the negative bias voltage. An external capacitor sets the delay time from  $AV_{DD}$  reaching final value to 23V appearing at the  $V_{ON}$  pin. The 3MHz switching frequency allows the use of tiny low profile chip inductors and capacitors throughout, providing a low noise, low cost total solution with all components under 1.25mm in height. The device operates from an input range of 2.6V to 6V and is available in an 8-lead MSOP package.

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## TYPICAL APPLICATION



### Start-Up Waveforms

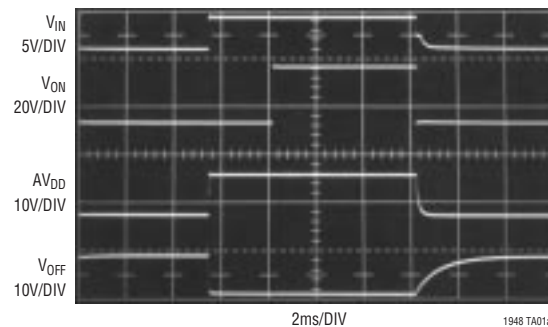


Figure 1. 3.3V Powered TFT-LCD Bias Generator

## ABSOLUTE MAXIMUM RATINGS

(Note 1)

$V_{IN}$ Voltage .....	8V
$C_T$ Voltage .....	6V
SW1, SW2 Voltage .....	36V
FB Voltage .....	3V
$V_{ON}$ , VO2 Voltage .....	30V
Operating Temperature Range (Note 2) ..	-40°C to 85°C
Lead Temperature (Soldering, 10 sec) .....	300°C

## PACKAGE/ORDER INFORMATION

	ORDER PART NUMBER
	LT1948EMS8
	MS8 PART MARKING
	LTNR

Consult factory for Industrial and Military grade parts.

## ELECTRICAL CHARACTERISTICS

The ● denotes the specifications which apply over the full operating temperature range, otherwise specifications are at  $T_A = 25^\circ\text{C}$ .  $V_{IN} = 3.3\text{V}$  unless otherwise specified.

SYMBOL	CONDITIONS	MIN	TYP	MAX	UNITS
Supply Current	Not Switching		7	13	mA
Reference Voltage			1.26		V
Reference Line Reg	$2.7\text{V} < V_{IN} < 8\text{V}$		0.01		%/V
$C_T$ Source Current	$V_{FB1} = 1.3\text{V}$	4.5	5.5	6.5	$\mu\text{A}$
$C_T$ Voltage to Turn On Q3		1.25	1.28	1.30	V
FB1 Voltage to Begin $C_T$ Charge		1.17	1.20	1.23	V
SW1 Current Limit	(Note 3)	1.2	1.5		A
SW2 Current Limit	(Note 3)	0.5	0.8		A
SW1 Saturation Voltage	$I_{SW1} = 800\text{mA}$		350	410	mV
SW2 Saturation Voltage	$I_{SW2} = 300\text{mA}$		250	300	mV
Oscillator Frequency		● 2.4	3.2	3.6	MHz
Maximum Duty Cycle	$0^\circ\text{C} \leq T_A \leq 85^\circ\text{C}$ $-40^\circ\text{C} \leq T_A \leq 0^\circ\text{C}$	● 70	75	90	%
		● 69			%
		● 67			%
VO2 Pin Resistance	Measured to Ground		400		$\text{k}\Omega$
SW1, SW2 Error Amp Gain			100		V/V
SW1, SW2 Error Amp Gm			50		$\mu\text{A}/\text{V}$
FB1 Regulation Voltage		● 1.240	1.260	1.280	V
		● 1.230		1.285	V
FB1 Line Regulation	$2.7\text{V} < V_{IN} < 8\text{V}$		0.01	0.05	
VO2 Regulation Voltage		22	23	24	V
$V_{ON}$ Switch Drop	$V_{O2} = 25\text{V}$ , 7mA Load from $V_{ON}$ , $C_T$ Voltage $> 1.30\text{V}$		200	260	mV
SW1 Leakage Current	Switch Off, SW1 Voltage = 3.3V		0.01	5	$\mu\text{A}$
SW2 Leakage Current	Switch Off, SW2 Voltage = 3.3V		0.01	2	$\mu\text{A}$

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

**Note 2:** The LT1948 is guaranteed to meet performance specifications from 0°C to 70°C. Specifications over the -40°C to 85°C operating

temperature range are assured by design, characterization and correlation with statistical process controls.

**Note 3:** Current limit guaranteed by design and/or correlation to static test.

## PIN FUNCTIONS

**FB1 (Pin 1):** Feedback Pin for First Switcher. Connect resistor divider tap here. Set  $AV_{DD}$  according to  $AV_{DD} = 1.26V(1 + R1/R2)$ .

**$C_T$  (Pin 2):** Timing Capacitor Pin. Connect a 22nF capacitor from  $C_T$  to ground to program a 3ms delay from FB1 reaching 1.26V to  $V_{ON}$  turning on.

**SW1 (Pin 3):**  $AV_{DD}$  Switch Node. Connect inductor and D1 here (see Figure 1). Minimize trace area at this pin to keep EMI down.

**GND (Pin 4):** Ground. Connect directly to local ground plane.

**$V_{IN}$  (Pin 5):** Input Supply Pin. Must be bypassed with a ceramic capacitor close to the pin.

**SW2 (Pin 6):**  $V_{O2}$  Switch Node. Connect inductor and D2 here. Minimize trace area at this pin to keep EMI down.

**$V_{O2}$  (Pin 7):** Sense Pin for 23V Output. Connect to  $V_{O2}$  output capacitor. This node is also internally connected to the emitter of Q3 (see Block Diagram), the high side switch between  $V_{O2}$  and  $V_{ON}$ .

**$V_{ON}$  (Pin 8):** This is the Delayed 23V Output.  $V_{ON}$  becomes 23V after the internal timer times out.

## OPERATION

To best understand operation of the LT1948, please refer to the LT1948 Block Diagram. The device contains two switching regulators, a timer and a high side switch. Three outputs can be generated: an adjustable  $AV_{DD}$  output, a charge-pumped inversion of the  $AV_{DD}$  output, called  $V_{OFF}$ , and a 23V/15mA output, called  $V_{ON}$ . Q3 keeps  $V_{ON}$  off for an externally set time interval, set by a capacitor connected to the  $C_T$  pin.

The switching frequency of both switchers is 3MHz, set internally. The switchers are current mode and are internally compensated. The main  $AV_{DD}$  switcher is current limited at 1.5A, while the second  $V_{ON}$  switcher is limited to 800mA. They share the same 1.26V reference voltage.

When the input voltage is below approximately 2.4V, an undervoltage lockout circuit disables switching.

When  $AV_{DD}$  is less than its final voltage, Q4 is turned on, holding the  $C_T$  pin at ground. When  $AV_{DD}$  reaches final value, Q4 lets go of the  $C_T$  pin, allowing the 5.5 $\mu$ A current source to charge the external capacitor,  $C_T$ . When the voltage on the  $C_T$  pin reaches 1.25V, Q3 turns on, connecting  $V_{O2}$  to  $V_{ON}$ . Capacitor value can be calculated using the following formula:

$$C = (5.5\mu A \cdot t_{DELAY})/1.25V$$

A 22nF capacitor results in approximately 3ms of delay.

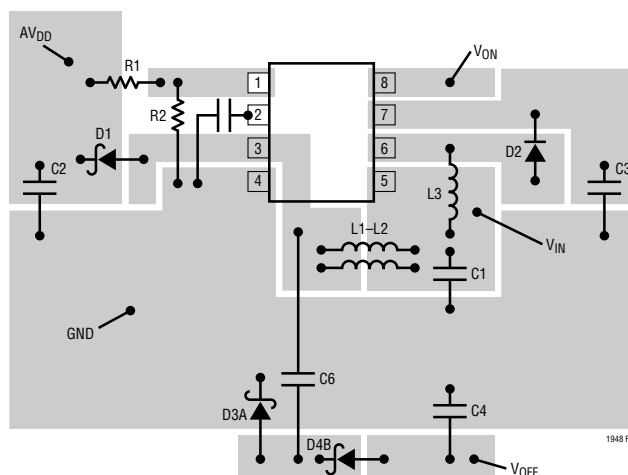
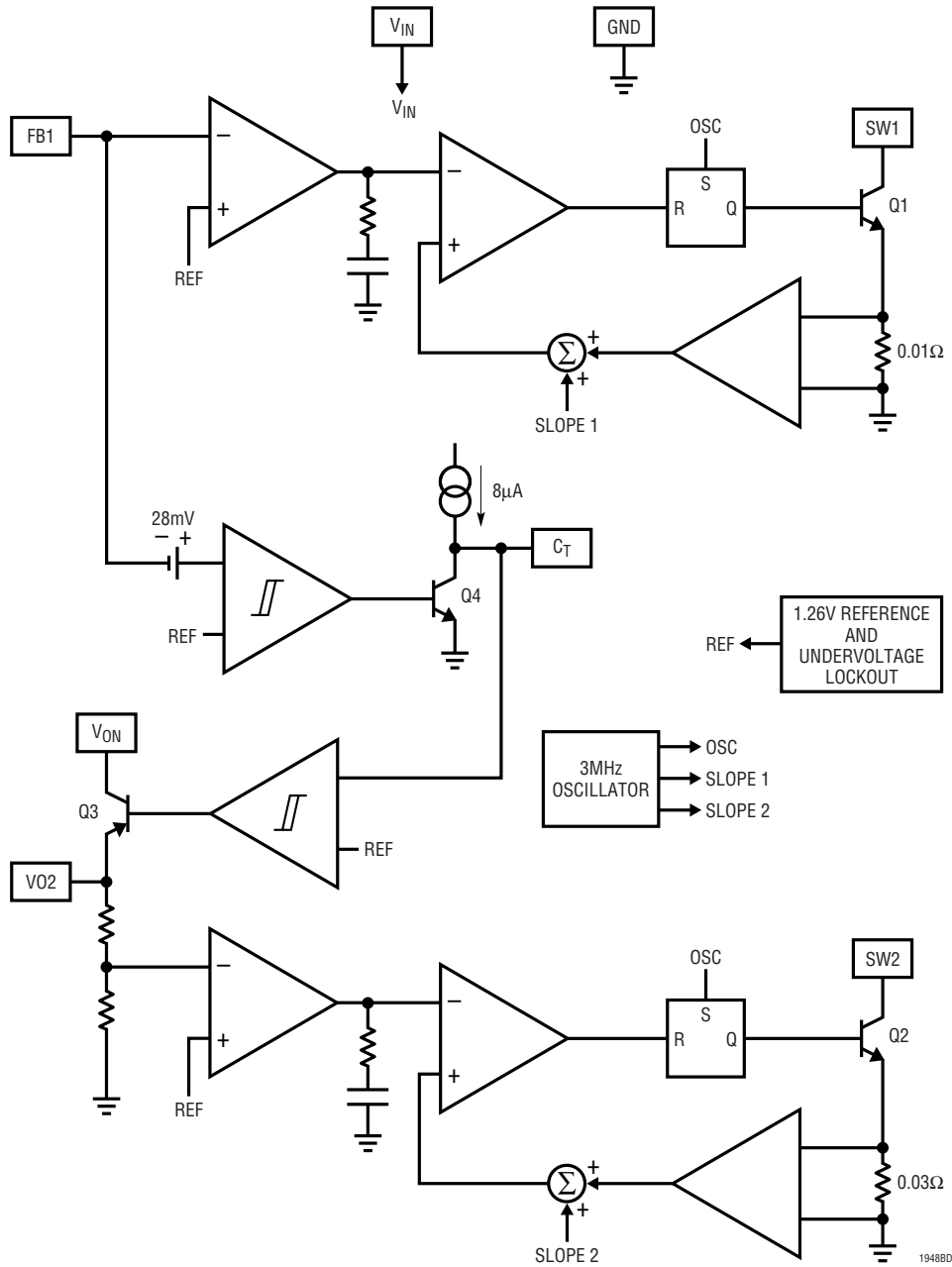


Figure 2. Recommended Component Placement

**BLOCK DIAGRAM**



1948BD

**RELATED PARTS**

PART NUMBER	DESCRIPTION	COMMENTS
LT1949	600kHz, 1A Switch PWM DC/DC Converter	10V at 175mA from 3.3V Input
LT1317	2-Cell Micropower DC/DC with Low-Battery Detect	3.3V at 200mA from 2-Cell Input
LT1308B	600kHz Single Cell Step-Up Regulator	5V at 1A from a 1-Cell Li-Ion Battery
LT1615	Micropower Step-Up Regulator in SOT-23	20V at 12mA from 2.5V Input, 5-Lead SOT-23 Package
LT1930	1.2MHz, Step-Up Regulator in SOT-23	5V at 480mA from 3.3V, 5-Lead SOT-23 Package