

## DESCRIPTION

DC1784A is a triple boost LED driver featuring the [LT3797](#) triple boost LED controller. It accepts an input voltage from 2.5V to 40V (with higher transient) and drives three independent strings of up to 50V LEDs at 1A. DC1784A features independent PWM and analog dimming of each of the three LED strings. Each of the three channels has its own short-circuit protection, open LED protection, and FAULT flag output.

Each or every channel can be altered to run as a different topology such as buck-boost mode, buck mode, or SEPIC depending upon the relationship between input and output voltage. Although the boost is set up to power 50V of LEDs at 1A, the maximum LED string voltage can be changed to almost 100V and the LED current can be adjusted by merely changing a few resistors and external components.

DC1784A features high efficiency at 310kHz switching frequency. At high LED string voltages up to 50V and 1A of LED current, the triple LED boost controller has 93.5% efficiency. The switching frequency can be adjusted between 100kHz and 1MHz with a single resistor. All three channels run in-phase with each other and an external SYNC pin can be used to set the switching frequency and phasing, as well as to optimize PWM dimming.

For low input voltage operation, down to 2.5V, the CTRL pin voltage is reduced as the input voltage drops below 10.5V, reducing LED brightness and restraining the peak switch currents in order to limit thermal rise on this PCB. The LT3797 has a unique, internal buck-boost INTV<sub>CC</sub> supply that powers the gate drivers at 7.8V, regardless of the state of the input voltage, rather than using an LDO from the input. UVLO turns the LEDs off when V<sub>IN</sub> drops below 2.5V. Internal OVLO turns off the switching when

the input exceeds 41V, but OVLO can be programmed externally to a lower voltage if desired. The LT3797 can withstand transients up to 60V. DC1784A can withstand transients up to 50V with C3 > 50V rating.

Small ceramic input and output capacitors are used to save space and cost. The open LED overvoltage protection uses the IC's constant voltage regulation loop to regulate the output to approximately 55V if the LED string is opened although it may reach 59V peak during transient from running LEDs to open. The unique FBH (feedback high) pins allow the overvoltage protection of non-grounded LED driver topologies such as buck-boost mode and buck mode to be accomplished with just two resistors.

Modifications can be made to DC1784A in order to convert the independent channels to higher or lower power or from LED drivers to constant voltage regulators. They can easily be changed from boost topology to SEPIC, buck mode, or buck-boost mode LED drivers. Please consult the factory or the LT3797 data sheet for details.

The LT3797 data sheet gives a complete description of the device, operation and applications information. The data sheet must be read in conjunction with this demo manual for DC1784A. The LT3797EUKG is assembled in a 52-lead (7mm × 8mm) plastic QFN UKG package with a thermally enhanced ground pad. Proper board layout is essential for maximum thermal performance. See the data sheet section 'Layout Considerations'.

**Design files for this circuit board are available at <http://www.linear.com/demo/DC1784A>**

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## PERFORMANCE SUMMARY

PARAMETER	CONDITIONS	VALUE (TYPICAL)
Input Voltage PVIN Range	Operating $V_{IN} = PVIN$	2.5V to $V_{LED}$ (Up to 40V)
Switching Frequency	$R1 = 47.5k$	310kHz
$I_{LED}$ CH1, CH2, CH3	$R2, R3, R4 = 0.25\Omega$ $10.5V < PVIN < V_{LED}$ (40V)	1.0A
Low PVIN $I_{LED}$ (CTRL foldback)	$R2, R3, R4 = 0.25\Omega$ $PVIN = 4.0V$ $R2, R3, R4 = 0.25\Omega$ $PVIN = 6.0V$ $R2, R3, R4 = 0.25\Omega$ $PVIN = 9.0V$	280mA 525mA 890mA
$V_{LED}$ Range CH1, CH2, CH3	$R8, R9, R10 = 23.2k$ $R14, R15, R16 = 1M$	$PVIN < V_{LED} < 50V$
Open LED Voltage CH1, CH2, CH3	$R8, R9, R10 = 23.2k$ $R14, R15, R16 = 1M$	55V
Typical Efficiency (100% PWM Duty Cycle)	$PVIN = 14V$ $V_{LED} = 50V$ and $I_{LED} = 1A$ CH1, CH2, CH3	93.5%
PVIN Under Voltage Lockout (Falling Turn-Off)	$R26 = 100k$ and $R27 = 105k$	2.5V
PVIN Under Voltage Lockout (Rising Turn-On)	$R26 = 100k$ and $R27 = 105k$	2.6V
INTV <sub>CC</sub>	Operating	7.5V
Peak Switch Current Limit CH1, CH2, CH3	$R11, R12, R13 = 0.008\Omega$	12.5A

## QUICK START PROCEDURE

DC1784A is easy to set up to evaluate the performance of the LT3797EUKG. Follow the procedure below:

1. Connect three strings of LEDs that will run with forward voltage less than 50V (at 1A), but greater than PVIN, to the LED<sup>+</sup> and GND terminals on the PCB as shown in Figure 1.
2. Connect the EN/UVLO terminal to GND.
3. With power off, connect the input power supply to the PVIN and GND terminals. Make sure that the PVIN DC input voltage does not exceed 40V (or  $V_{LED}$ ).
4. Turn the input power supply on and make sure the voltage is between 2.5V and 40V (or  $V_{LED}$ ).
5. Connect the PWM1-3 input terminals to INTV<sub>CC</sub> or  $V_{REF}$  to enable 100% brightness control when EN/UVLO is released.
6. Release the EN/UVLO-to-GND connection.
7. Observe the LED strings running at the programmed LED current.
8. To change the brightness with analog dimming, simply attach a voltage source on any or all of the CTRL terminals and set the voltage(s) between 0V and 1.5V. See data sheet for details.
9. To change brightness with PWM dimming, remove the connection from PWM1-3 to INTV<sub>CC</sub> or  $V_{REF}$  and attach a 3.3V to 5V rectangular waveform with varying duty cycle.

## DEMO CIRCUIT OPTIONS

DC1784A can be adjusted for higher output voltage, different LED current, or different topology. The following options are for simple changes to the demonstration circuit. The data sheet gives more information regarding designing with the LT3797. For more information, see the data sheet for details or contact Linear Technology technical support.

### Maximum LED Voltage

DC1784A is set for 55V of overvoltage protection and the maximum LED string voltage used on the standard build should be 50V. However, the output can go up to 100V, so OVP can be set at about 93V for maximum LED voltage and the maximum LED string voltage is therefore about 87V. The limits are based upon open LED overshoot and voltage and current regulation regions. If changes are made in the FB resistors for higher voltage, the MOSFET and catch diode should be switched out for higher voltage devices. See the LT3797 data sheet for details.

### Current or Voltage Regulation

The LT3797 can be used for constant current or voltage regulation. If the load placed on the LED<sup>+</sup> to GND terminals allows  $V_{OUT}$  to climb high enough for  $V_{ISP-FBH} = 1.2V$ , then the voltage regulation loop of the converter takes over. In this case, the compensation for a given channel should be adjusted for proper use as a constant voltage regulator. The IC can be used as a boost or SEPIC constant voltage regulator. Output voltage can be almost as high as 100V when used as a constant voltage regulator.

### LED Current and Switch Current

LED current on DC1784A is set for 1A with 0.25Ω resistors R2, R3, R4. For a different maximum LED current, change this resistor:

$$250\text{mV}/R_{LED} = I_{LED}$$

A change in LED current or input voltage may lead to higher or lower maximum switch current. R11, R12, R13 can be changed to alter the maximum switch current for different applications.  $100\text{mV}/R_{SENSE} = \text{peak switch current}$ .

### Overvoltage Protection

Overvoltage protection is set with resistor pairs R8 & R14, R9 & R15, R10 & R16. The high side feedback method allows simple changes for different topologies.

For buck mode and buck-boost mode, see the data sheet for details how to set the feedback resistors. Note that R35, R36, R37 are provided as optional placeholders on the demo circuit for simple feedback resistor changes for these topologies.

### BOOST, BUCK MODE, BUCK-BOOST MODE, SEPIC

Any channel of the DC1784A can be changed to a different topology than boost. A few simple changes including feedback overvoltage protection feedback resistors, output resistor, components, and connection to input can be made. Please consult the LT3797 data sheet and the factory for details.

### Undervoltage and Overvoltage Lockout

UVLO can be adjusted by changing the values of R26 and R27.

The LT3797 has an internal 41V OVLO that protects the IC from switching at high input voltage transients. However, an additional OVLO pin can be used to set a lower OVLO using resistors R28, R31, and/or R46.

## DEMO CIRCUIT OPTIONS

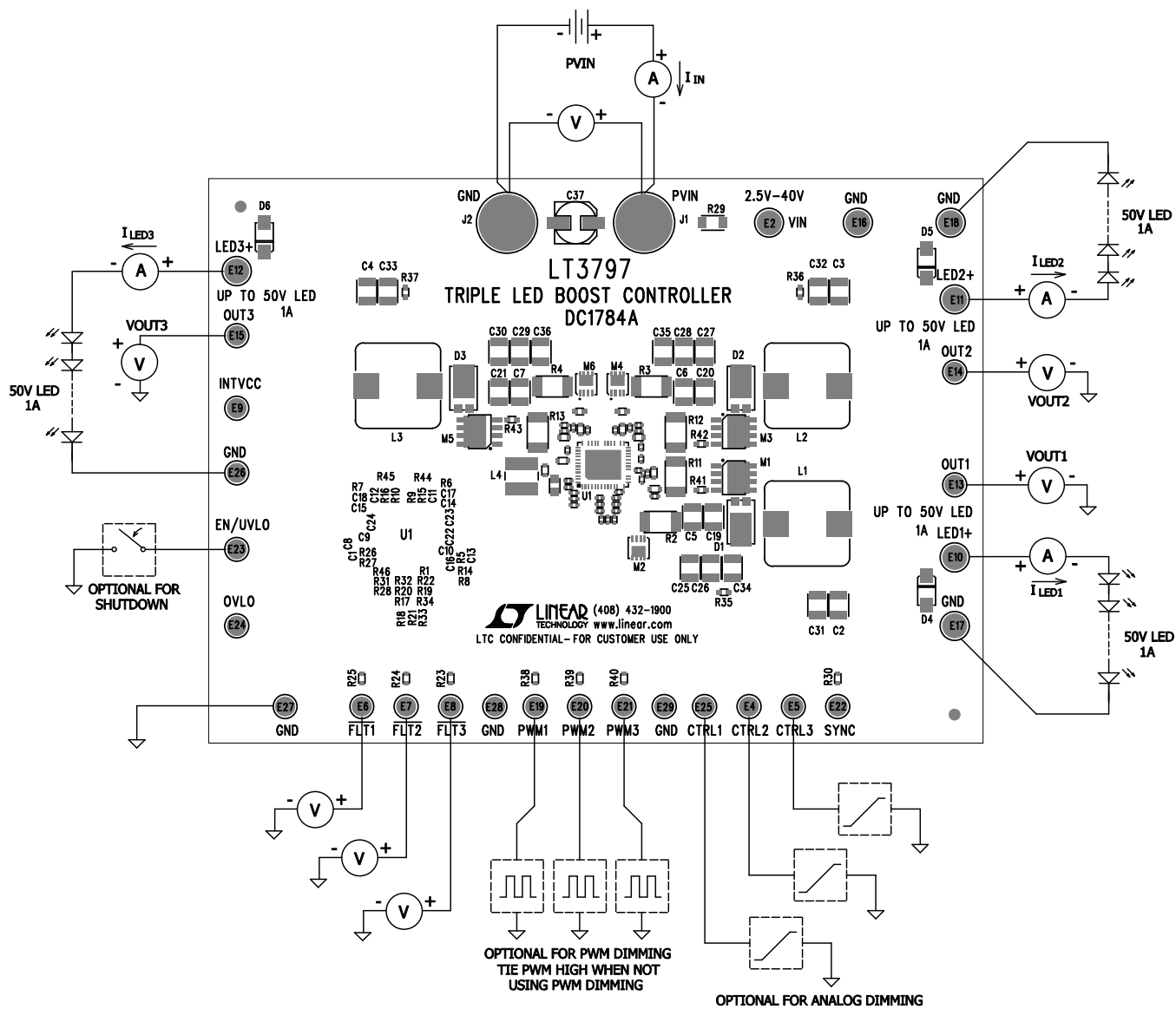


Figure 1. Test Procedure Setup Drawing for DC1784A

## DEMO CIRCUIT OPTIONS

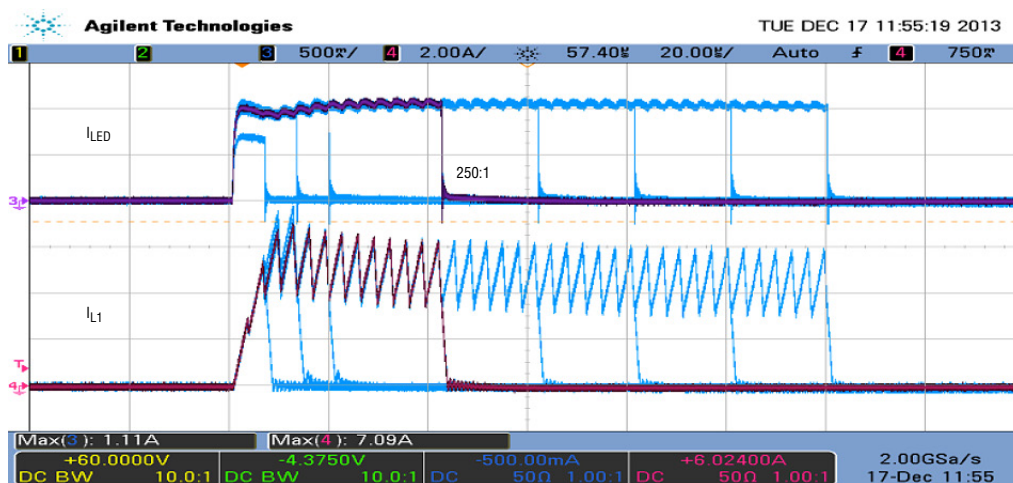


Figure 2. DC1784A 12V<sub>IN</sub> 100Hz PWM Dimming Waveforms at Different PWM Duty Cycles with 250:1 in Bold. I<sub>LED</sub> Waveform (500mA/Div) Is on Top (with 50V LED String) and I<sub>L1</sub> Waveform (2A/Div) Is on the Bottom

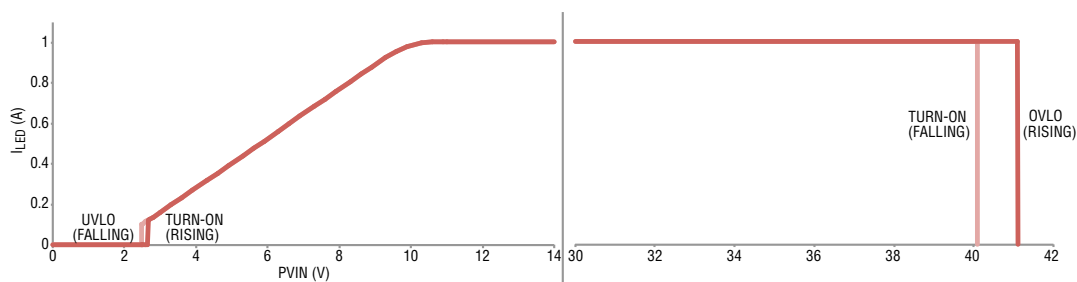


Figure 3. DC1784A CTRL LED Current Foldback at Low P<sub>VIN</sub> with UVLO Falling and Rising

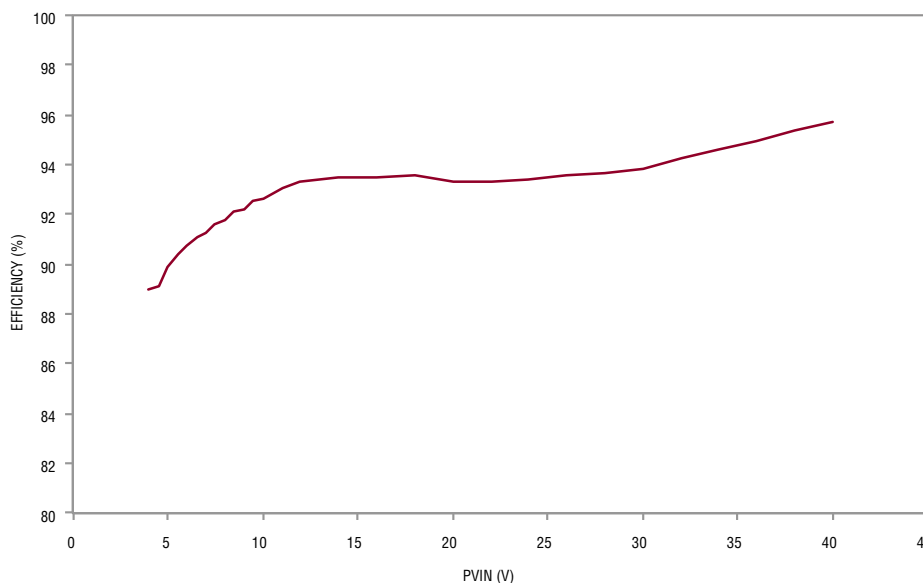


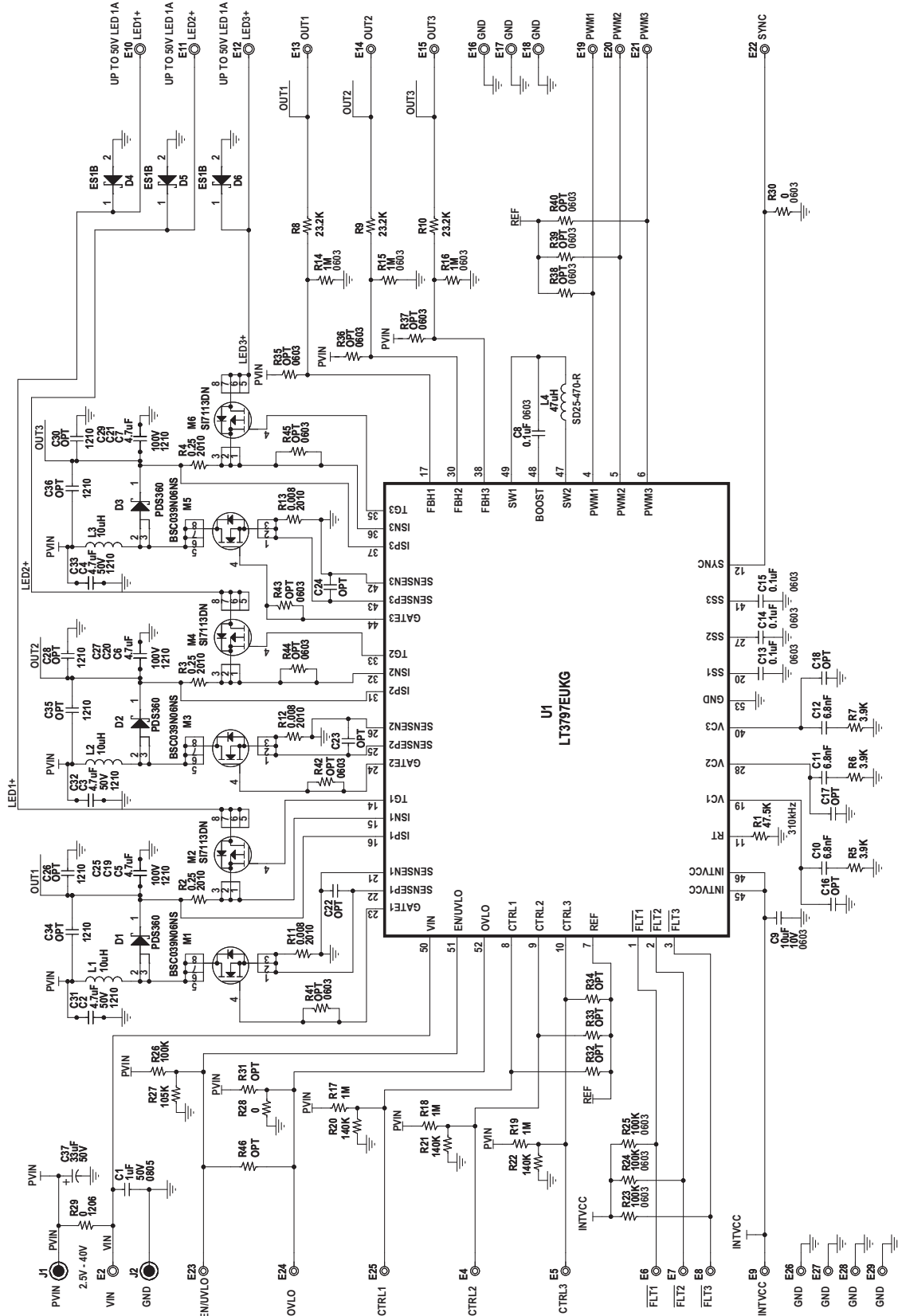
Figure 4. DC1784A Efficiency at Maximum I<sub>LED</sub> vs P<sub>VIN</sub> with 50V LEDs (at 1A) on All Three Channels

# DEMO MANUAL DC1784A

## PARTS LIST

ITEM	QTY	REFERENCE	PART DESCRIPTION	MANUFACTURER/PART NUMBER
<b>Required Circuit Components</b>				
1	1	C1	Cap., X7R, 1 $\mu$ F, 50V, 10%, 0805	MURATA, GRM21BR71H105KA12L
2	6	C2, C3, C4, C31, C32, C33	Cap., X7R, 4.7 $\mu$ F, 50V, 10%, 1210	MURATA, GRM32ER71H475KA88L
3	9	C5, C6, C7, C19, C20, C21, C25, C27, C29	Cap., X7S, 4.7 $\mu$ F, 100V, 20%, 1210	TDK C3225X7S2A475M
4	4	C8, C13, C14, C15	Cap., X7R, 0.1 $\mu$ F, 10V, 10%, 0603	AVX, 0603ZC104KAT2A
5	1	C9	Cap., X5R, 10 $\mu$ F, 10V, 20%, 0603	SAMSUNG CL10A106MP8NUNC
6	3	C10, C11, C12	Cap., X7R, 6800pF, 25V, 10%, 0402	AVX, 04023C682KAT2A
7	3	D1, D2, D3	DIODE, PDS360, POWERDI-5	DIODES/ZETEX, PDS360-13
8	3	L1, L2, L3	IND, 10 $\mu$ H, HC9-100-R	COILTRONICS, HC9-100-R
9	1	L4	IND., 47 $\mu$ H, SD SERIES, IND-SD25	COILTRONICS, SD25-470-R
10	3	M1, M3, M5	Mosfet, N-Channel, BSC039N06NS, PWRPAK SO-8	INFINEON, BSC039N06NS
11	3	M2, M4, M6	Mosfet, P-Channel, SI7113DN, PWRPAK1212-8	VISHAY, SI7113DN-T1-GE3
12	1	R1	RES., CHIP, 47.5k, 1/16W, 1%, 0402	VISHAY, CRCW040247K5FKED
13	3	R2, R3, R4	RES., CHIP, 0.25 $\Omega$ , 1W, 1%, 2010	IRC, LRC-LR2010LF-01-R250-F
14	3	R5, R6, R7	RES., CHIP, 3.9k, 1%, 0402	VISHAY, CRCW04023K90FKED
15	3	R8, R9, R10	RES., CHIP, 23.2k, 1/16W, 1%, 0402	VISHAY, CRCW040223K2FKED
16	3	R11, R12, R13	RES., CHIP, 0.008 $\Omega$ , 1W, 1%, 2010	SEI, CSRF2010FT8L00
17	3	R14, R15, R16	RES., CHIP, 1M, 1/10W, 1%, 0603	VISHAY, CRCW06031M00FKEA
18	1	U1	IC, LT3797EUKG QFN(52)(UKG)-7mm $\times$ 8mm	LINEAR TECH.CORP. LT3797EUKG#PBF
<b>Optional Electrical Components</b>				
1	0	C16, C17, C18, C22, C23, C24	CAP., OPT 0402	OPT
2	0	C26, C28, C30, C34, C35, C36	CAP., OPT 1210	OPT
3	1	C37	Cap., ALUM, 33 $\mu$ F, 50V, 6.3 $\times$ 7.7	PANASONIC, EEHZA1H330XP
4	3	D4, D5, D6	DIODE, ES1B, 150V/1A, SMA	DIODES/ZETEX, ES1B-13-F
5	3	R17, R18, R19	RES., CHIP, 1M, 1/16W, 1%, 0402	VISHAY, CRCW04021M00FKED
6	3	R20, R21, R22	RES., CHIP, 140k, 1/16W, 1%, 0402	VISHAY, CRCW0402140KFKED
7	3	R23, R24, R25	RES., CHIP, 100k, 1/10W, 1%, 0603	VISHAY, CRCW0603100KFKEA
8	1	R26	RES., CHIP, 100k, 1/16W, 1%, 0402	VISHAY, CRCW0402100KFKED
9	1	R27	RES., CHIP, 105k, 1/16W, 1%, 0402	VISHAY, CRCW0402105KFKED
10	1	R28	RES., CHIP, 0 $\Omega$ , 0402	VISHAY, CRCW04020000Z0ED
11	1	R29	RES., CHIP, 0 $\Omega$ , 1/4W, 1%, 1206	VISHAY, CRCW12060000Z0EA
12	1	R30	RES., CHIP, 0 $\Omega$ , 1/10W, 1%, 0603	VISHAY, CRCW06030000Z0EA
13	0	R31 to R34, R46	RES., OPT, 0402	OPT
14	0	R35 to R45	RES., OPT, 0603	OPT
<b>Hardware</b>				
1	7	E2, E10, E11, E12, E16, E17, E18	TESTPOINT, TURRET 0.094"	MILLMAX, 2501-2-00-80-00-00-07-0
2	20	E4 to E9, E13 to E15, E19 to E29	TESTPOINT, TURRET 0.064"	MILL-MAX, 2308-2-00-80-00-00-07-0
3	2	J1, J2	CONNECTOR, BANANA JACK	KEYSTONE, 575-4

## SCHEMATIC DIAGRAM



# DEMO MANUAL DC1784A

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Mailing Address:

Linear Technology  
1630 McCarthy Blvd.  
Milpitas, CA 95035

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