LT8393 $60V_{IN}$, $100V_{OUT}$ Synchronous 4-Switch Buck-Boost LED Driver with Low EMI

DESCRIPTION

Demonstration circuit 2865A is a synchronous 4-switch buck-boost LED driver featuring the LT®8393. This demonstration circuit drives a single string of LEDs up to 70V at 300mA. DC2865A runs from an input voltage of 9V to 18V as-built and is capable of $4V_{IN}$ to $60V_{IN}$ if UVLO is adjusted. It runs at 350kHz switching frequency and features spread spectrum modulation (SSFM) which spreads the switching frequency from f_{SW} to f_{SW} + 25%. Both analog and PWM dimming are featured. DC2865A features undervoltage lockout (UVLO) set at 7.9V with 1.4V hysteresis for turn-on.

The LT8393 has an adjustable switching frequency between 350kHz and 2MHz. The SYNC jumper also allows external frequency synchronization.

The LT8393 can be PWM dimmed for accurate brightness control with an external PWM signal and an internally-generated PWM signal. DC2865A has a jumper that can be set to switch between internally-generated PWM signal, externally-generated PWM signal, and no PWM signal (100% on). It can be analog dimmed with a control voltage on its CTRL pin.

When run with both PWM dimming and spread spectrum, the spread spectrum aligns itself with the PWM signal for flicker-free operation.

The LT8393 features both open LED and short LED (LED^+ to GND) protection as well as a fault output flag.

Small ceramic input and output capacitors save space and cost. The open LED overvoltage protection uses the IC's constant voltage regulation loop to regulate the output to approximately 70V if the LED string is opened.

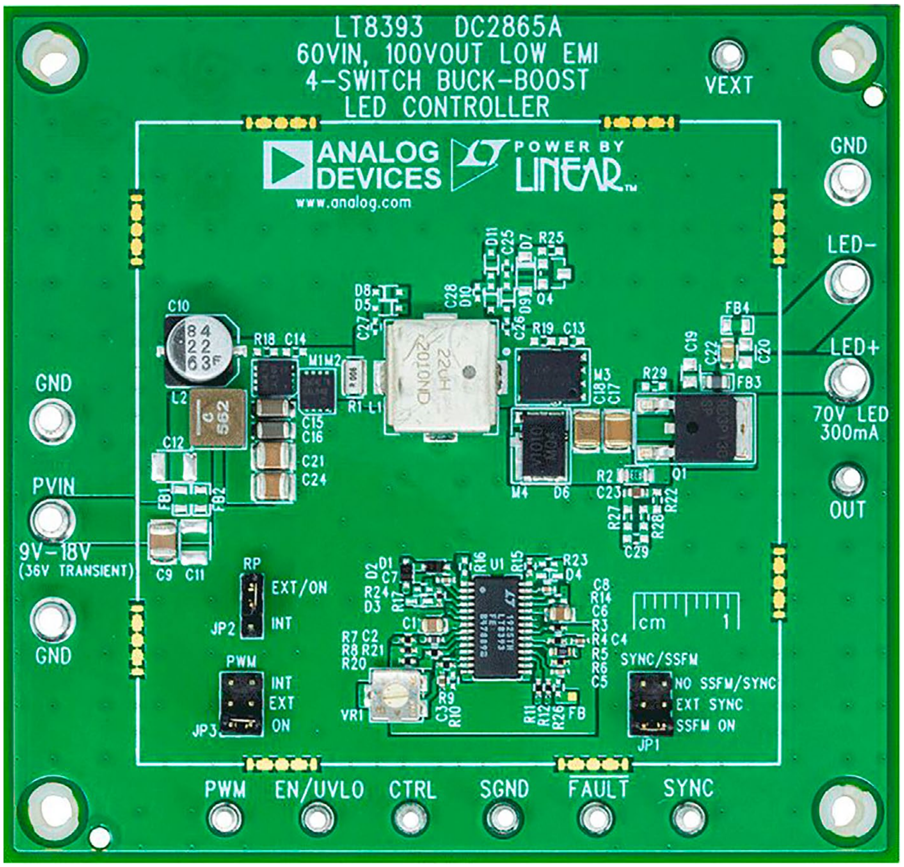
The input and output EMI filters on the demo circuit reduce the EMI of this power converter. This is intended for automotive applications where CISPR25 Class 5 standards are observed. Additionally, gate resistors and grounded shield can be added on the demo circuit for further EMI reduction if necessary. In non-automotive applications, where EMI may not be as important, the input and output filter can be removed for higher efficiency.

The UVLO voltage, LED current, output voltage range, switching frequency, brightness control, and SSFM can all be adjusted with simple modifications to the demonstration circuit.

The LT8393 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 DC2865A. The LT8393JFE is assembled in a 28-lead plastic TSSOP package with a thermally enhanced GND.

Design files for this circuit board are available.

BOARD PHOTO



PERFORMANCE SUMMARY

Specifications are at T_A = 25°C

PARAMETER	CONDITION	MIN	TYP	MAX	UNIT
Input Voltage PV_{IN} Range	Operating 24V ≤ V_{LED} ≤ 70V	4		60	V
Switching Frequency (f_{SW})	R3 = 422kΩ, SSFM = OFF R3 = 422kΩ, SSFM = ON		350 350 – 437.5		kHz kHz
LED Current I_{LED}	R2 = 330mΩ, 9V < V_{IN} < 18V 24V ≤ V_{LED} ≤ 70V, V_{CTRL} = 2V	297	300	303	mA
LED Voltage V_{LED} Range	R5 = 1MΩ, R6 = 11.3kΩ, R26 = OPEN	24		70	V
Open LED Voltage V_{OUT}	R5 = 1MΩ, R6 = 11.3kΩ, R26 = OPEN	88	94	98	V
Efficiency (100% PWM DC)	12.0V V_{IN}, 350kHz, 24 LEDs, SSFM = ON		90		%
Internally-Generated PWM Dimming Range	JP2 = INT, JP3 = INT	1/16384		100	%
Internally-Generated PWM Dimming Frequency	JP2 = INT, JP3 = INT R21 = 51kΩ, R3 = 422kΩ		350		Hz
Peak Switch Current Limited Boost Region	R1 = 0.006Ω		8		A
Peak Switch Current Limited Buck Region	R1 = 0.006Ω		8		A
PV_{IN} Undervoltage Lockout (UVLO) Falling	R7 = 499kΩ, R8 = 127kΩ		6.1		V
PV_{IN} Enable Turn-On (EN) Rising	R7 = 499kΩ, R8 = 127kΩ		7.3		V

QUICK START PROCEDURE

NOTE: Make sure that the voltage applied to V_{IN} does not exceed 60V.

The DC2865A is easy to set up to evaluate the performance of the LT8393. Refer to Figure 1 for proper measurement equipment setup and follow the procedure below.

1. With power off, connect a string of LEDS that will run with a forward voltage less than or equal to 70V at 300mA to the LED^+ and LED^- terminals on the PCB as shown in Figure 1.
2. Connect the EN/UVLO terminal to GND.
3. For always-on LED operation: Set JP2 to EXT/ON and JP3 to ON. Set JP1 to NO SSFM/SYNC to run without SSFM.
4. With power off, connect the input power supply to the V_{IN} and GND terminals.
5. Turn the input power supply on and make sure the voltage is between 9V and 18V to start operation.
6. Release the EN/UVLO-to-GND connection.
7. Observe the LED string running at the programmed LED current.
8. To change the brightness with analog dimming, simply attach a voltage source to the CTRL terminal and set the voltage between 0V and 2V. See data sheet for details.
9. To change brightness with external PWM dimming, set JP2 to **E**XT/ON and JP3 to EXT. Keep LED wire length to a minimum to achieve higher dimming ratios. Attach a 0V – 3V rectangular waveform with varying duty cycle to the PWM terminal.
10. To change brightness with internally-generated PWM dimming, set JP2 to INT and JP3 to INT. Adjust the setting of VR1 variable resistor with a small flathead screwdriver to toggle between 0% and 100% PWM dimming duty cycle in 1/128 steps.
11. To enable spread spectrum frequency modulation, set JP1 to SSFM ON.

QUICK START PROCEDURE

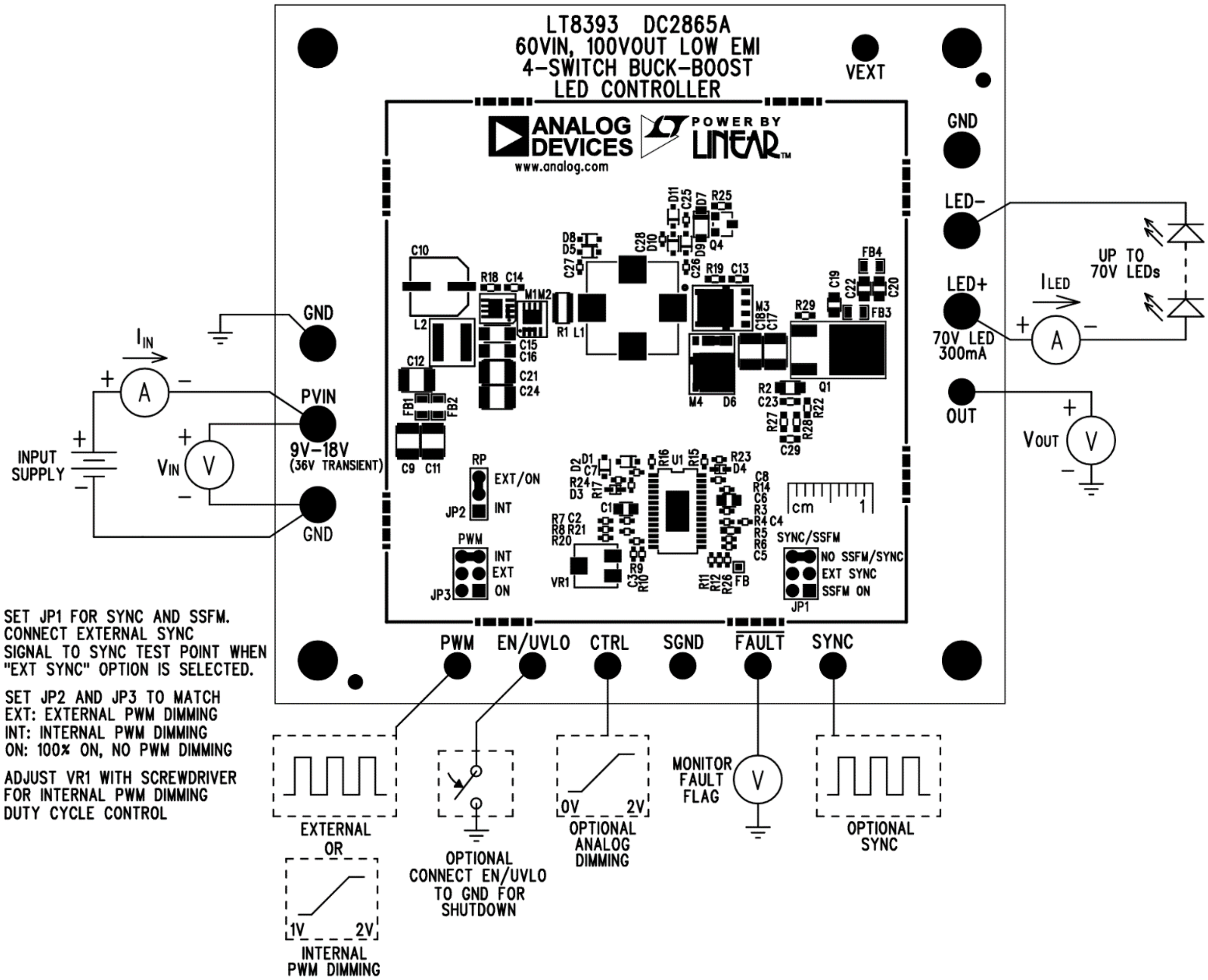


Figure 1. Test Procedure Setup Drawing for DC2865A

TEST RESULTS

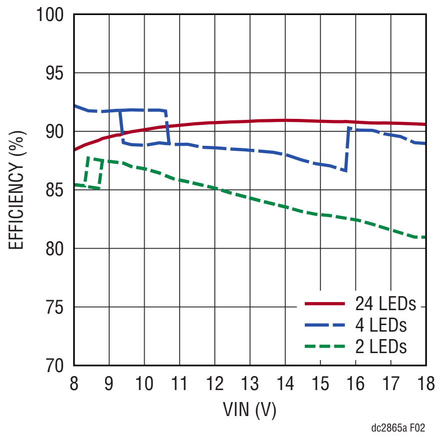


Figure 2. DC2865A Efficiency vs Input Voltage with 350kHz and various LED strings at 300mA with SSFM ON

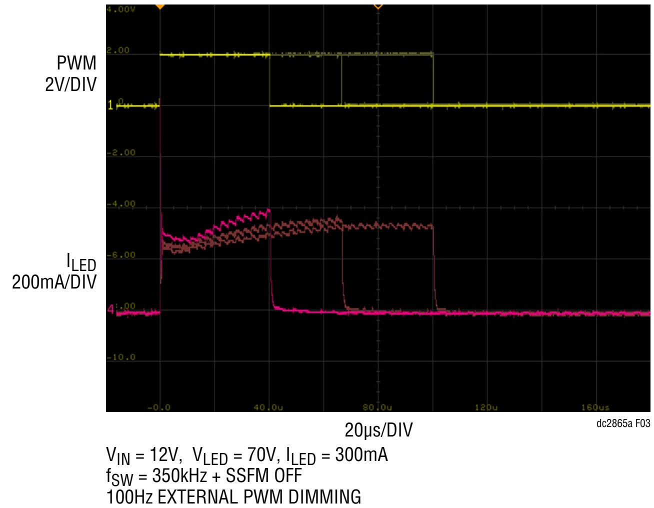


Figure 3. DC2865A High Performance External PWM Dimming with LEDs connected between LED$^+$ and LED$^-$

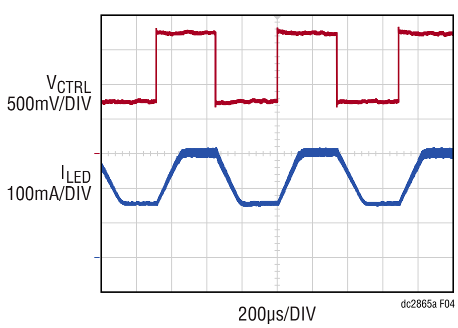


Figure 4. DC2865A 50% to 100% I_{LED} Load Transient with CTRL Input with SSFM On, $12V_{IN}$ and $70V_{LED}$

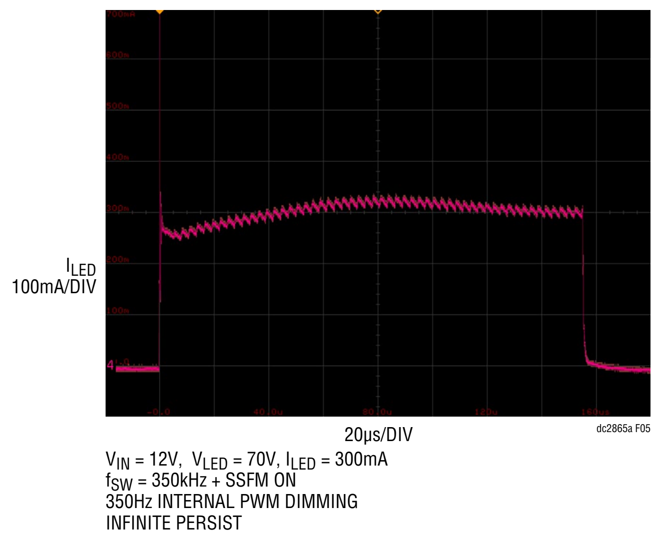
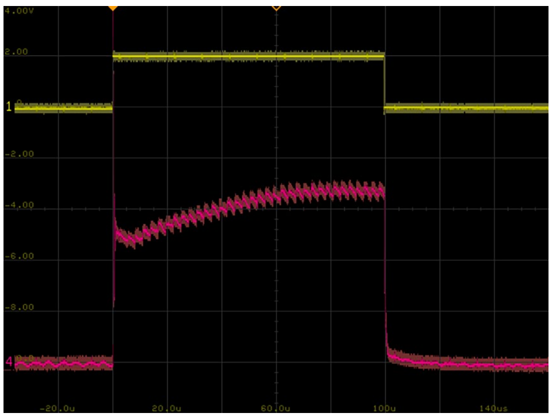


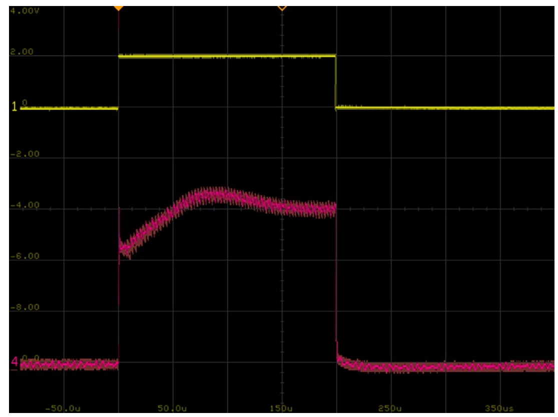
Figure 5. Infinite-Persist Scope Shows Internal PWM Dimming and SSFM Working Together for Flicker-Free Brightness Control

TEST RESULTS



V_{IN} = 12V, V_{LED} = 70V, I_{LED} = 300mA
f_{SW} = 350kHz + SSFM OFF
100Hz EXTERNAL PWM DIMMING
INFINITE PERSIST

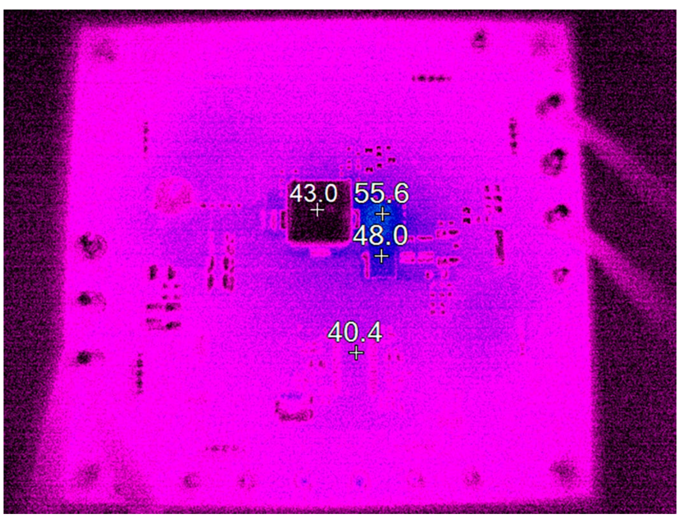
(a)



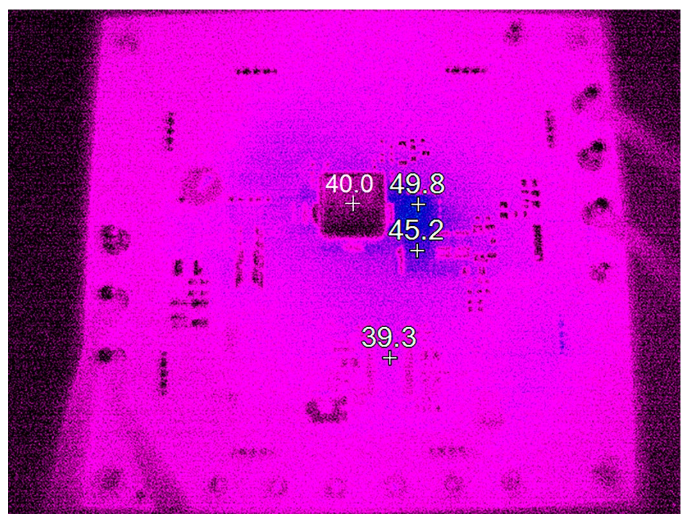
V_{IN} = 12V, V_{LED} = 70V, I_{LED} = 300mA
f_{SW} = 350kHz + SSFM ON
100Hz EXTERNAL PWM DIMMING
INFINITE PERSIST

(a)

Figure 6. Infinite-Persist Scope Shows External PWM Dimming and SSFM Working Together for Flicker-Free Brightness Control



(a) 9V_{IN}



(b) 12V_{IN}

Figure 7. Thermal Image with V_{LED} = 70V, I_{LED} = 300mA, SSFM On

Rev. 0

EMISSION RESULT

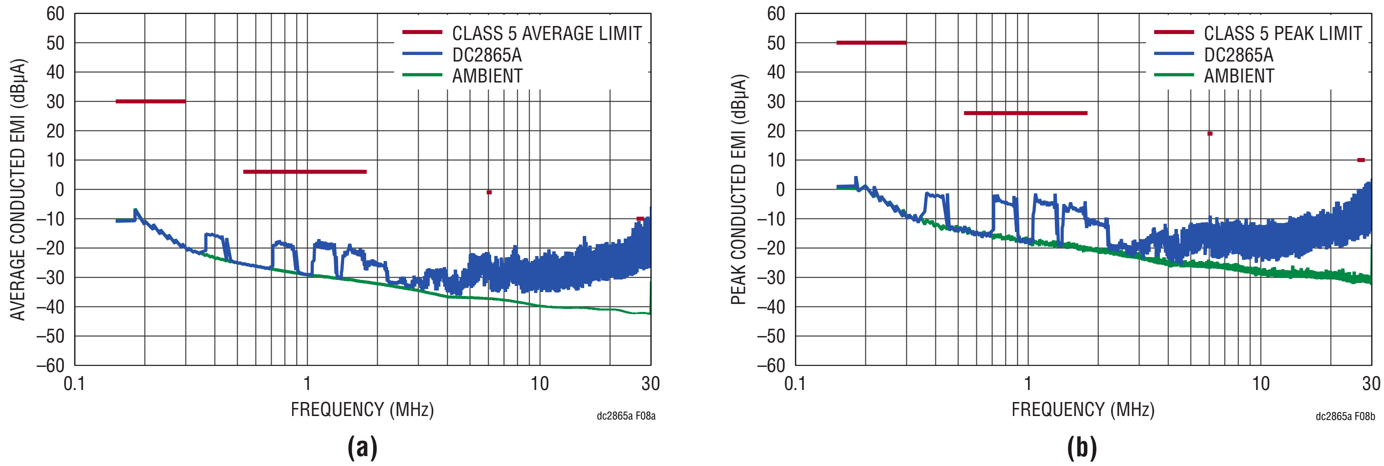


Figure 8. Average and Peak Conducted Emissions Performance Using Current Method with CISPR25 Limits

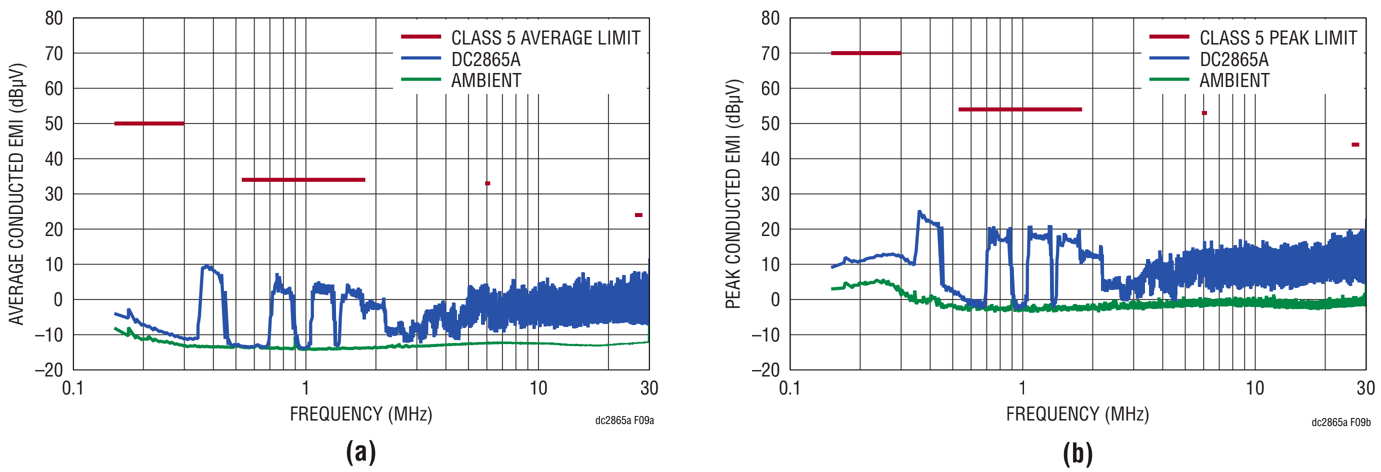


Figure 9. Average and Peak Conducted Emissions Performance Using Voltage Method with CISPR25 Limits

EMISSION RESULT

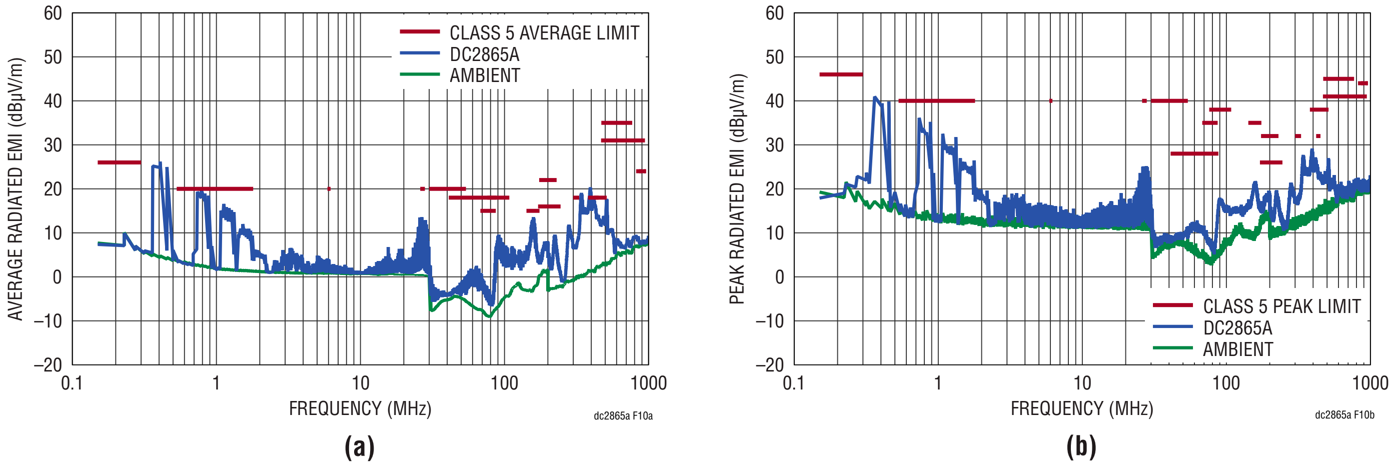


Figure 10. CISPR25 Average and Peak Radiated Emissions Performance with CISPR25 Limits

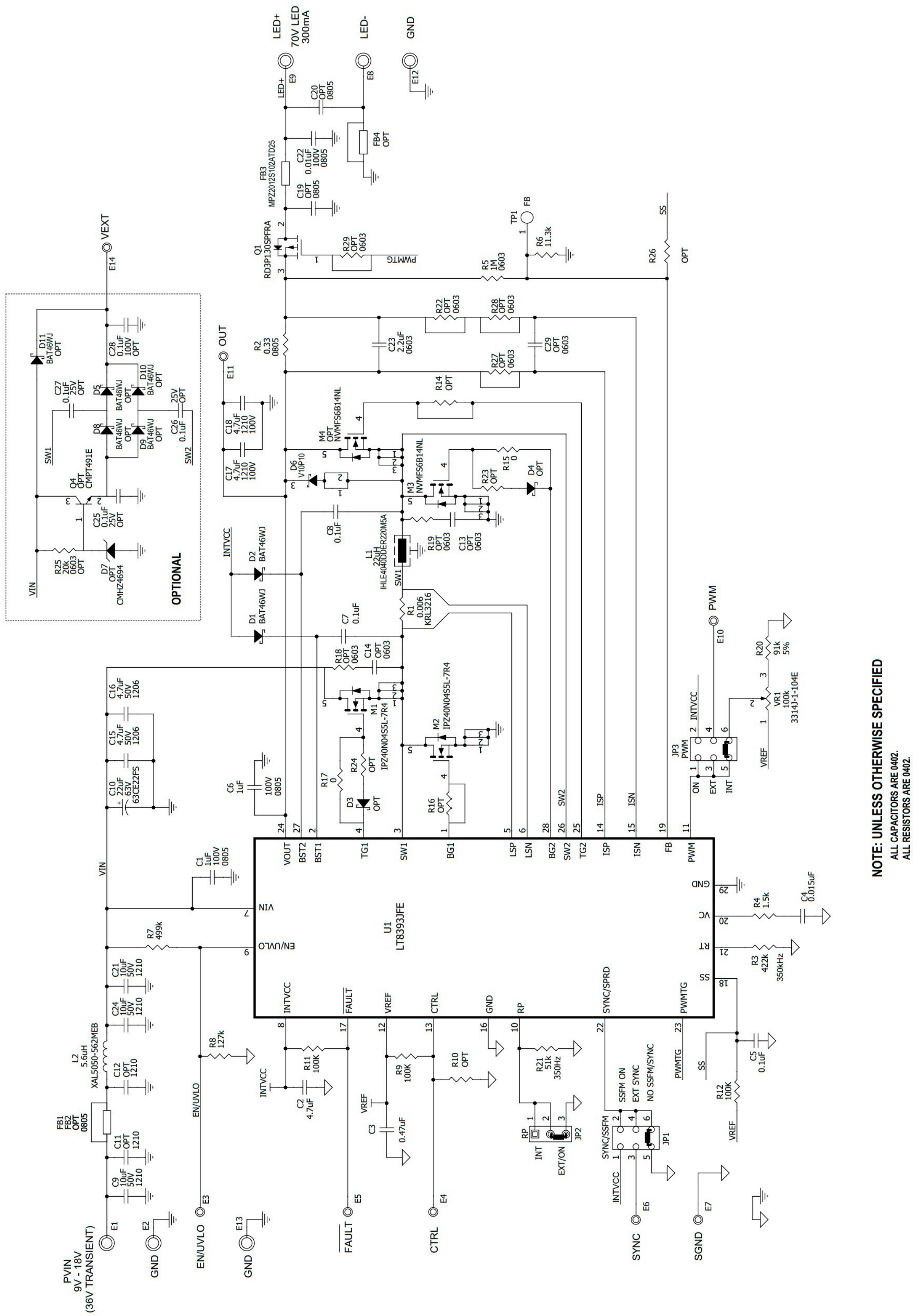
PARTS LIST

ITEM	QTY	REFERENCE	PART DESCRIPTION	MANUFACTURER/PART NUMBER
Required Circuit Components				
1	2	C1, C6	CAP., X7S, 1µF, 100V, 10% 0805, AEC-Q200	MURATA, GCM21BC72A105KE36L
2	1	C2	CAP., X5R, 4.7µF, 10V, 10% 0402	TDK, C1005X5R1A475K050BC
3	1	C3	CAP., X5R, 0.47µF, 16V,10% 0402	MURATA, GRM155R61C474KE01D
4	1	C4	CAP., X7R, 0.015µF, 16V, 10% 0402	MURATA, GRM155R71C153KA01J
5	3	C5, C7, C8	CAP., X7R, 0.1µF, 25V, 10% 0402	AVX, 04023C104KAT2A
6	2	C9, C24	CAP., X7S, 10µF, 50V, 10% 1210, AEC-Q200	MURATA, GCM32EC71H106KA03L
7	1	C10	CAP., ALUM, 22µF, 63V, 20%, SMD 6.3mm × 7.7mm	SUN ELECTRONICS INDUSTRIES CORP, 63CE22FS
8	2	C15, C16	CAP., X7S, 4.7µF, 50V, 10% 1206, AEC-Q200	MURATA, GCM31CC71H475KA03K
9	2	C17, C18	CAP., X7S, 4.7µF, 100V, 10% 1210, AEC-Q200	MURATA, GCM32DC72A475KE02L
10	1	C21	CAP., X7S, 10µF, 50V, 10% 1210, AEC-Q200	MURATA, GCM32EC71H106KA03L
11	1	C22	CAP., X7R, 0.01µF, 100V, 10% 0805, AEC-Q200	MURATA, GCD21BR72A103KA01L
12	2	D1, D2	DIODE, SCHOTTKY, 100V, 250mA, SOD-323F, AEC-Q101	NEXPERIA, BAT46WJ,115
13	1	D6	DIODE, SCHOTTKY, 100V, 10A, SMPC (TO-277A), AEC-Q101	VISHAY, V1010HM_A/H
14	1	L1	IND., 22µH, PWR, SHIELDED, 20%, 4.1A, 75.44mΩ, 4040DD, IHLE-5A SERIES, AEC-Q200	VISHAY, IHLE4040DDER220M5A
15	1	L2	IND., 5.6µH, PWR, SHIELDED, 20%, 7.2A , 25.80mΩ, 5.28mm × 5.48mm, AEC-Q200	COILCRAFT, XAL5050-562MEB
16	2	M1, M2	XSTR., MOSFET, N-CH, 40V, 40A, PG-TSDSON-8-32, AEC-Q101	INFINEON, IPZ40N04S5L-7R4
17	2	M3, M4	XSTR., MOSFET, N-CH, 100V, 11A, DFN5 (SO-8FL), AEC-Q101	ON SEMICONDUCTOR, NVMFS6B14NLT1G
18	1	Q1	XSTR., MOSFET, P-CH, 100V, 13A, DPAK (TO-252), AEC-Q101	ROHM, RD3P130SPFRATL
19	1	R1	RES., 0.006Ω, 1%, 1.5W, 1206, LONG-SIDE TERM, SENSE, AEC-Q200	SUSUMU, KRL3216E-C-R006-F-T1
20	1	R2	RES., 0.33Ω, 1%, 1/3W, 0805, SHORT-SIDE TERM., SENSE	SUSUMU, RL1220S-R33-F
21	1	R3	RES., 422k, 1%, 1/16W, 0402, AEC-Q200	NIC, NRC04F4223TRF
22	1	R4	RES., 1.5k, 1%, 1/16W, 0402, AEC-Q200	NIC, NRC04F1501TRF
23	1	R5	RES., 1M, 1%, 1/10W, 0603, AEC-Q200	NIC, NRC06F1004TRF
24	1	R6	RES., 11.3k, 1%, 1/16W, 0402, AEC-Q200	NIC, NRC04F1132TRF
25	2	R15, R17	RES., 0Ω, 1/16W, 0402	NIC, NRC04ZOTRF
26	1	U1	IC, LED DRIVER CTRLR, TSSOP-28	ANALOG DEVICES, LT8393JFE#WPBF

PARTS LIST

ITEM	QTY	REFERENCE	PART DESCRIPTION	MANUFACTURER/PART NUMBER
Additional Demo Board Components				
27	2	C11, C12	CAP., OPTION, 1210	
28	3	C13, C14, C29	CAP., OPTION, 0603	
29	2	C19, C20	CAP, OPTION, 0805	
30	1	C23	CAP., X7S, 2.2µF, 10V, 10% 0603, AEC-Q200	TDK, CGA3E3X7S1A225K080AB
31	1	C28	CAP., X5R, 0.1µF, 100V, 10% 0402	MURATA, GRM155R62A104KE14D
32	2	D3, D4	DIODE, OPTION, SOD-532	
33	5	D5, D8, D9, D10, D11	DIODE, SCHOTTKY, 100V, 250mA, SOD-323F, AEC-Q101	NEXPERIA, BAT46WJ,115
34	1	D7	DIODE, OPTION, SOD-123	
35	2	FB1, FB2	IND., FERRITE BEAD, OPTION, 0805	
36	1	FB3	IND., 1k AT100MHz, FERRITE BEAD, 25%, 1.5A, 150mΩ, 0805, AEC-Q200	TDK, MPZ2012S102ATD25
37	1	Q4	XSTR., OPTION, NPN, SOT-23	
38	1	R7	RES., 499k, 1%, 1/16W, 0402, AEC-Q200	NIC, NRC04F4993TRF
39	1	R8	RES., 127k, 1%, 1/16W, 0402	VISHAY, CRCW0402127KFKED
40	3	R9, R11, R12	RES., 100k, 1%, 1/16W, 0402, AEC-Q200	NIC, NRC04F1003TRF
41	5	R10, R14, R16, R23, R24	RES., OPTION, 0402	
42	5	R18, R19, R22, R27, R28	RES., OPTION, 0603	
43	1	R20	RES., 91k, 5%, 1/16W, 0402, AEC-Q200	NIC, NRC04J913TRF
44	1	R21	RES., 51k, 1%, 1/16W, 0402, AEC-Q200	NIC, NRC04F5102TRF
45	1	R46	RES., 20k, 1%, 1/10W, 0603	NIC, NRC06F2002TRF
46	1	VR1	RES., 100k, 20%, 1/4W, SMD 4mm SQ, 1-TURN, TOP ADJ., TRIMPOT	BOURNS, 3314J-1-104E
Hardware: For Demo Board Only				
47	6	E1, E2, E8, E9, E12, E13	TESTPOINT, TURRET, 0.094" PBF	MILL-MAX, 2501-2-00-80-00-00-07-0
48	8	E3, E4, E5, E6, E7, E10, E11, E14	TESTPOINT, TURRET, 0.061" PBF	MILL-MAX, 2308-2-00-80-00-00-07-0
49	2	JP1, JP3	HEADER 3-PIN 0.079" DOUBLE ROW	WURTH ELEKTRONIK, 62000621121
50	1	JP2	HEADER 2-PIN 0.079" DOUBLE ROW	WURTH ELEKTRONIK, 62000311121
51	4	MH1, MH2, MH3, MH4	STANDOFF, NYLON, SNAP-ON, 0.375"	WURTH ELEKTRONIK, 702933000
52	3	XJP1, X JP2, XJP3	CONN., SHUNT, FEMALE, 2-POS, 2mm	WURTH ELEKTRONIK, 60800213421

SCHEMATIC DIAGRAM



ESD Caution

ESD (electrostatic discharge) sensitive device. Charged devices and circuit boards can discharge without detection. Although this product features patented or proprietary protection circuitry, damage may occur on devices subjected to high energy ESD. Therefore, proper ESD precautions should be taken to avoid performance degradation or loss of functionality.