

FEB157-001 User's Guide Offline High Brightness LED Driver Evaluation Board

Featured Fairchild Product: FAN7554



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1. Introduction

1.1 Product Description

A high brightness LED evaluation board has been developed using the Fairchild Semiconductor FAN7554D PWM controller. The board has the capability of driving one, two or three Lumiled, or similar LEDs. The output current is user selectable at 350mA, 700mA, or 1A. The current is selectable by inserting or removing jumpers JP1 and JP2 on the evaluation board. The board is designed to operate over the universal AC line range of 90Vac to 270Vac. A picture of the board is shown in Figure 1.

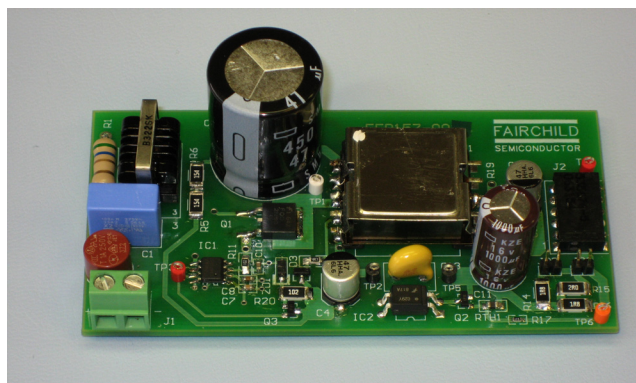


Figure 1: Offline High Brightness LED Driver Board

1.2 Circuit Description

The FEB157 evaluation board is an offline flyback converter utilizing the PWM controller, FAN7554D. Rather than controlling the output voltage, it is designed to control the LED load current. This is the preferred technique to drive high brightness LEDs. Controlling the LED current allows for a constant brightness as well as long life of the LEDs. The schematic of the FEB157 is shown in Figure 3 below.

Referring to Figure 3, the input AC line voltage comes in through J1. Capacitor C1, and common mode line choke, LF1, form the conducted EMI filter. The dc resistance of LF1 and R1 limit the inrush current at turn on. Diode bridge BD1 and filter capacitor C2 convert the ac voltage to an unregulated dc voltage. Resistors R5 and R6 provide the initial startup current for the FAN7554D. Capacitor C8 off of pin 2 of the FAN7554D provides for soft start in that the pulse width will gradually increase slowly at turn on thereby decreasing the stress on Q1. Once the converter is up and running the operating bias voltage will come from the auxiliary winding (pins 4–5) on transformer T1.

The oscillator frequency of the FAN7554D is set by an RC network, R10 and C9. In this board the frequency is set to 100kHz. However, the FAN7554D can be operated as high as 500kHz.

The FAN7554D is a current mode PWM controller. Current mode operation implies that there are two control loops. An inside loop that controls the current through the primary winding of the transformer and an outer loop that controls the output voltage. However, as previously stated, in this application the outer loop will actually provide feedback information regarding the LED load current instead of the output voltage.

Since the output current is being controlled instead of the output voltage, the output voltage will actually vary with the number of LEDs on the output. The same applies to the auxiliary winding that provides the bias supply to the FAN7554D. Consequently, the transformer had to be designed to provide enough bias when powering one LED. Then when powering three LEDs, the bias voltage is significantly higher. In order to maintain reliable operation, a regulator circuit consisting of R20, ZD1 and Q3 is implemented. This circuit will regulate the voltage to the Vcc pin of the FAN7554 to 18V when there are multiple LEDs on the output. Please note that this circuit would not be needed in a conventional application where the number of LEDs on the output is known and fixed. In such an application, the transformer would then be designed to provide the required Vcc voltage for that particular number of LEDs.

The FAN7554D will take feedback information from the sense resistor, R12, and from the feedback pin, pin 1, and generate a PWM signal that is applied to the FET at location Q1. This FET, FDQ2N80, is a 2A, 800V, N-channel MOSFET in a DPAK package. As with any flyback converter, energy is stored in the transformer while the FET is on, and released to the secondary when the FET is turned off. Since no transformer can be constructed with perfect coupling, the network consisting of resistors R2, R3, R4, diode D1 and capacitor C3 clamp the resulting leakage inductance spike so that it does not endanger Q1.

The transformer, T1, is constructed on an EFD20 core/bobbin. The energy stored in the transformer during the on time of Q1 is delivered to the secondary during the off time of Q1. Diode D4, and C11 rectify and filter the resulting secondary waveform to form a dc voltage. Inductor L1 and capacitor C12 provide additional attenuation of any residual switching spikes on the output voltage. Connector J2 is a Tyco six position connector (p/n 535676-5) that will mate with Future Electronics LED “Emitter” boards to carry the dc power to the LEDs. A picture of a three LED assembly is shown in Figure 2.

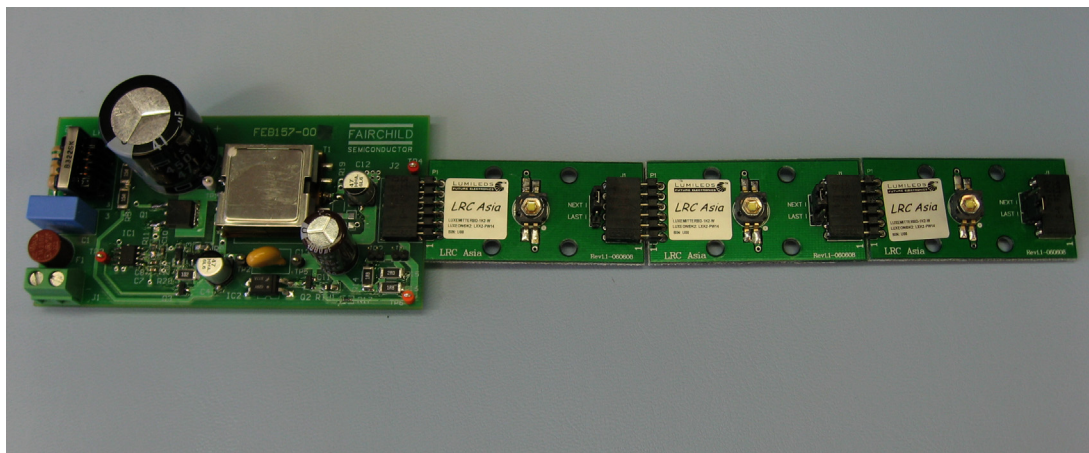


Figure 2: Offline LED Driver and LED Assembly

As previously mentioned, when driving high brightness LEDs the objective is to control the LED current. There are different ways of controlling the current. In this evaluation board a method utilizing sense resistors and an NPN transistor is used. Referring to the schematic in Figure 3, resistors R14, R15, and R16 are the resistors that sense the return current from the LED load. Jumpers JP1 and JP2 allow the selection of the output current. Table 1 describes the jumper status for particular output currents.

Table 1: Jumper JP1/JP2 Status and LED Current

LED Current	JP1 Status	JP2 Status
350mA	Out	Out
700mA	In	Out
1A	In	In

Refer to the schematic in Figure 3. As the LED current returns back to the power supply, it develops a voltage across the sense resistor(s). Once this voltage reaches the base-emitter junction voltage of the NPN Q2, typically about 650mV, the transistor will conduct collector current. This current also flows through the photodiode inside the optocoupler, IC2. The optocoupler will transfer this feedback information optically across the primary-secondary boundary to the primary side of the supply thereby maintaining the necessary isolation. Thermistor RTH1, is a negative temperature coefficient device and compensates for changes in base-emitter voltage due to temperature change.

2. Electrical Requirements

2.1 Input Requirements

Voltage range: 90Vrms to 270Vrms

Frequency: 47Hz to 63Hz

2.2 Output Requirements

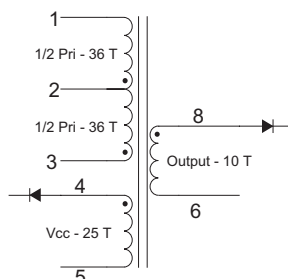
The FEB157 board will power one, two, or three high brightness LEDs (Lumiled or similar) at user selectable load currents of 350mA, 700mA, or 1A.

3.2 Transformer

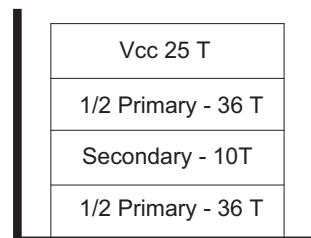
Required Components

Core = EFD20
Bobbin = 10 pin; SMD; Horizontal

Schematic



Winding Stackup



Electrical Specifications

	Pin	Spec.	Remarks
Inductance	1 - 3	537.0 - 656.0 uH	100 kHz, 0.10 Vrms
Leakage	1 - 3		All other windings shorted

3.3 Bill of Materials

Sch Ref	Vendor	Part Number	Description
BD1	Fairchild	DF10S	1.5A, 1000 V Bridge
C1	NIC Components or Equivalent	NPX104M275VX2M	0.1µF, X2 cap
C2	NIC Components	NREH470M450V18X36F	47µF, 450V
	UCC	ESMH451ESN470MN25S	47µF, 450V
C3	TDK	C4520X7R3A102KT	1000 pF, 1kV, SMD
C4	NIC Components or Equivalent	NACK470M50V6.3X8TR	47µF, 50V, SMD
C5	NIC Components or Equivalent	NMC0603X7R104K50TRP	0.1µF, 50V, 0603
C6	NIC Components or Equivalent	NMC0603X7R103K50TRP	0.01µF, 50V, 0603
C7	NIC Components or Equivalent	NMC0603X7R104K50TRP	0.1µF, 50V, 0603
C8	NIC Components or Equivalent	NMC0603X7R105K16TRP	1.0µF, 16V, 0603
C9	NIC Components or Equivalent	NMC0603NPO182F25TRP	1800 pF, 25V, 0603, NPO
C10	NIC Components or Equivalent	NMC0603X7R471K50TRP	470 pF, 50V, 0603
C11	NIC Components or Equivalent	NRSJ102M16V10X16TB	1000µF, 16V, Leaded
C12	NIC Components or Equivalent	NACK470M50V6.3X8TR	47µF, 50V, SMD
C13	Panasonic	ECK-NVS222ME	2200pF, Y-rated cap
C14			Prov. for 0805
C15	TDK	C4520CH3F101K	100 pF, 3kV, SMD

3.3 Bill of Materials (Continued)

Sch Ref	Vendor	Part Number	Description
Conn1	Phoenix Contact	1729018	2 position terminal block
Conn2	Tyco	535676-5	6 position connector
D1	Fairchild	RS1M	1A, 1000V, SMA
D2	Fairchild	Prov. for MMBD4148	
D3	Fairchild	BAS21	0.2A, 250V, SOT-23
D4	Fairchild	SS39	3A, 90V, SMC
F1	Littlefuse	3721100	1A, 250V, Slo-Blo
IC1	Fairchild	FAN7554D	PWM Controller, SO-8
IC2	Fairchild	FOD817A	Optocoupler
JP1	Sullins	PRPN021PAEN-RC	2 pin header (2mm)
JP2	Sullins	PRPN021PAEN-RC	2 pin header (2mm)
JP1	Sullins	STN02SYBN-RC	2 pin shunt
JP2	Sullins	STN02SYBN-RC	2 pin shunt
L1	Coilcraft	DO1608C-222	2.2 μ H
LF1	Sumida	UU9LFBNP-B322	3.2mH
Q1	Fairchild	FQD2N80	2A, 800V, N-channel, DPAK
Q2	Fairchild	MMBT2222AK	0.6A, 40V, NPN
Q3	Fairchild	MMBT2222AK	0.6A, 40V, NPN
R1	NIC Components or Equivalent	NCF100J5R6TR	5.6 Ω , 1 W
R2	NIC Components or Equivalent	NRC50J223TR	22k Ω , 1/2 W, 2010
R3	NIC Components or Equivalent	NRC50J223TR	22k Ω , 1/2 W, 2010
R4	NIC Components or Equivalent	NRC12J100TR	10 Ω , 1/4 W, 1206
R5	NIC Components or Equivalent	NRC50J154TR	150k Ω , 1/2 W, 2010
R6	NIC Components or Equivalent	NRC50J154TR	150k Ω , 1/2 W, 2010
R7	NIC Components or Equivalent	NRC10J220TR	22 Ω , 1/8 W, 0805
R8	NIC Components or Equivalent	NRC06J103TR	10k Ω , 1/10 W, 0603
R9	NIC Components or Equivalent	NRC10J4R7TR	4.7 Ω , 1/8 W, 0805
R10	NIC Components or Equivalent	NRC06F1002TR	10k Ω , 1/10 W, 1%, 0603
R11	NIC Components or Equivalent	NRC10J102TR	1k Ω , 1/8 W, 0805
R12	NIC Components or Equivalent	NRC100J1R2TR	1.2 Ω , 1 W, 2512
R13			Prov. for 2512
R14	NIC Components or Equivalent	NRC50J1R8TR	1.8 Ω , 3/4 W, 2010
R15	NIC Components or Equivalent	NRC50J2R0TR	2.0 Ω , 3/4 W, 2010
R16	NIC Components or Equivalent	NRC50J1R8TR	1.8 Ω , 3/4 W, 2010

3.3 Bill of Materials (Continued)

Sch Ref	Vendor	Part Number	Description
R17	NIC Components or Equivalent	NRC06J511TR	510Ω, 1/10 W, 0603
R18	NIC Components or Equivalent	NRC06J101TR	100Ω, 1/10 W, 0603
R19			Prov. for 2010
R20	NIC Components or Equivalent	NRC50J102TR	1kΩ, 3/4 W, 2010
R21	NIC Components or Equivalent	NRC50J470TR	47Ω, 3/4 W, 2010
RTH1	NIC Components or Equivalent	NCT08AJ104334TR	10kΩ, NTC Thermistor, Beta = 3340
T1	Cooper	CTX0117893	EFD20 Core/Bobbin Transformer
TP1	Keystone	5002	PC Test Point-White
TP2	Keystone	5001	PC Test Point-Black
TP3	Keystone	5000	PC Test Point-Red
TP4	Keystone	5000	PC Test Point-Red
TP5	Keystone	5001	PC Test Point-Black
TP6	Keystone	5003	PC Test Point-Orange
ZD1	Fairchild	MMSZ5248B	18V, 1/2W, SOD-123
ZD2			Prov. for SOD-123

3.4 Printed Circuit Board

The PCB is a double sided board made of FR4 with 1oz copper.

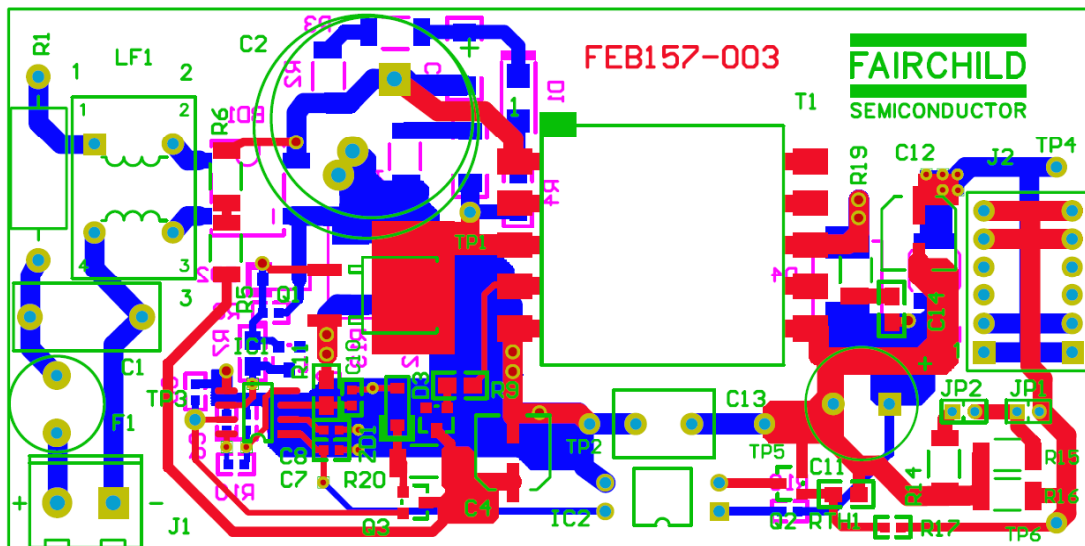


Figure 4: Silkscreen/Component Placement of PCB Layout

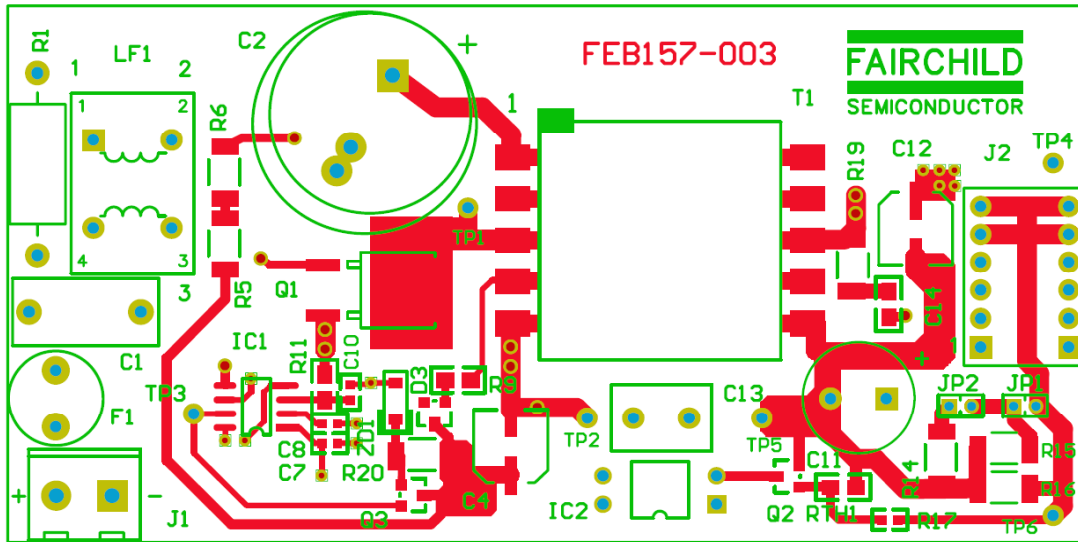


Figure 5: Silkscreen/Component Placement of Top Side Layer

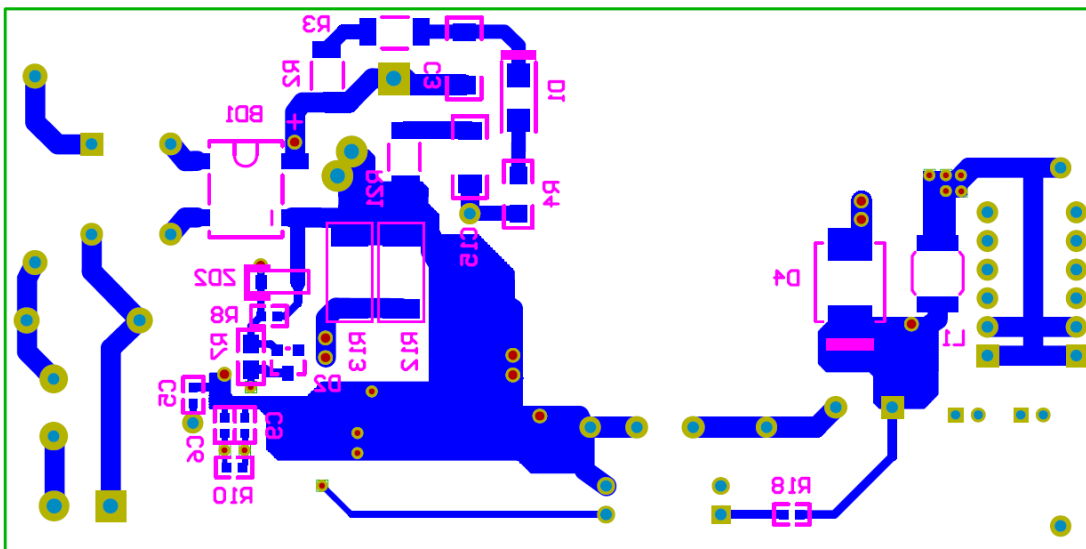


Figure 6: Silkscreen/Component Placement of Bottom Side Layer

4. Test Results

4.1 Regulation

4.1.1 Line Regulation

This graph illustrates the regulation of the output current over line voltage for the three possible settings, 350mA, 700mA, and 1A.

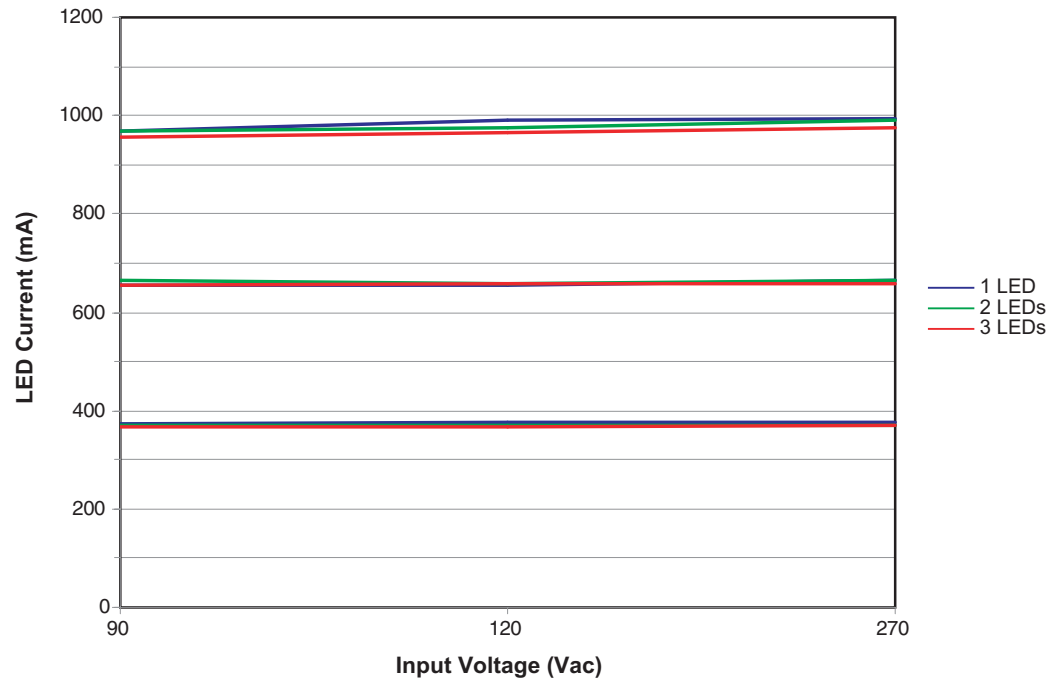


Figure 7: LED Current vs. Line Voltage

4.2 Efficiency

The efficiency data shown is for the converter with a load of one, two and three LEDs driven at 1A.

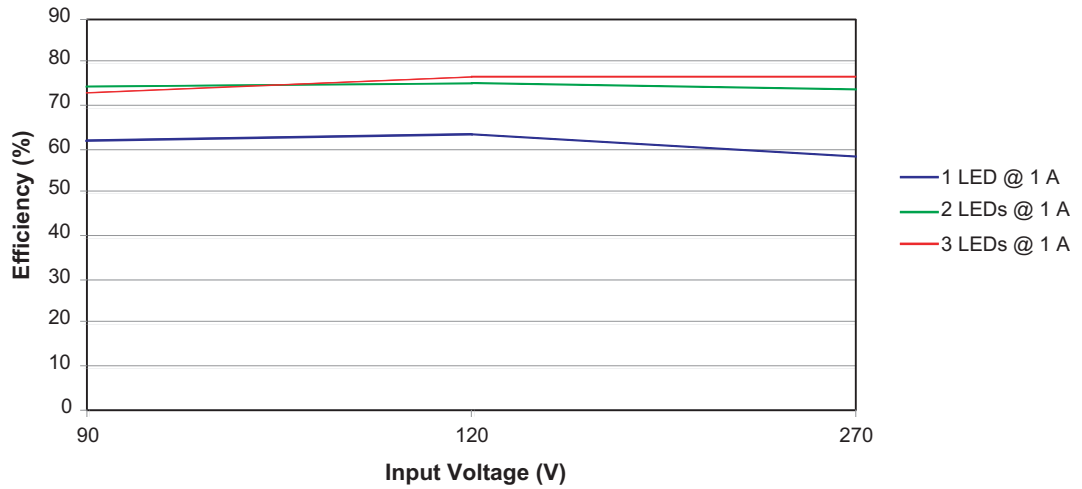


Figure 8: Converter Efficiency Data Plotted Against Increasing Line Input for LED Current of 1A.

4.3 Steady State Operation

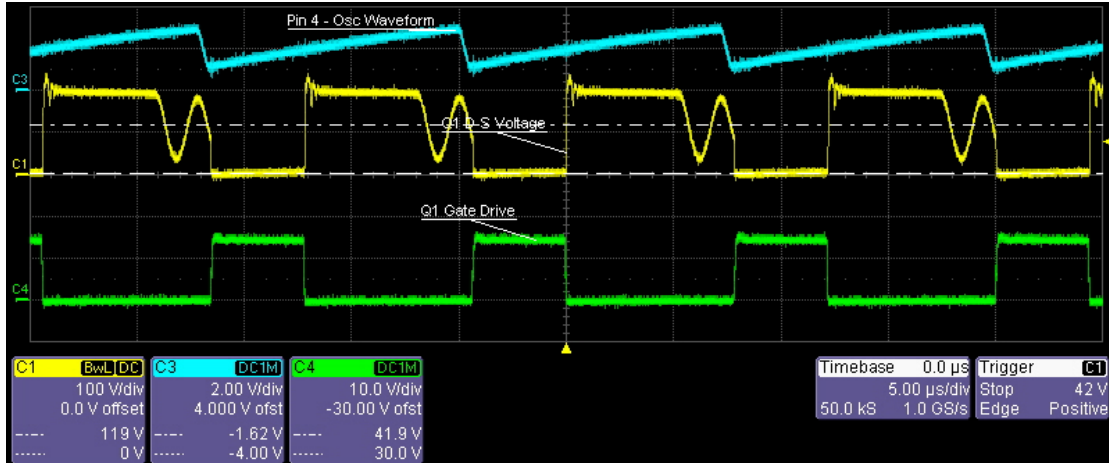


Figure 9: Steady State Waveforms at 90Vac with Three LEDs at 1A

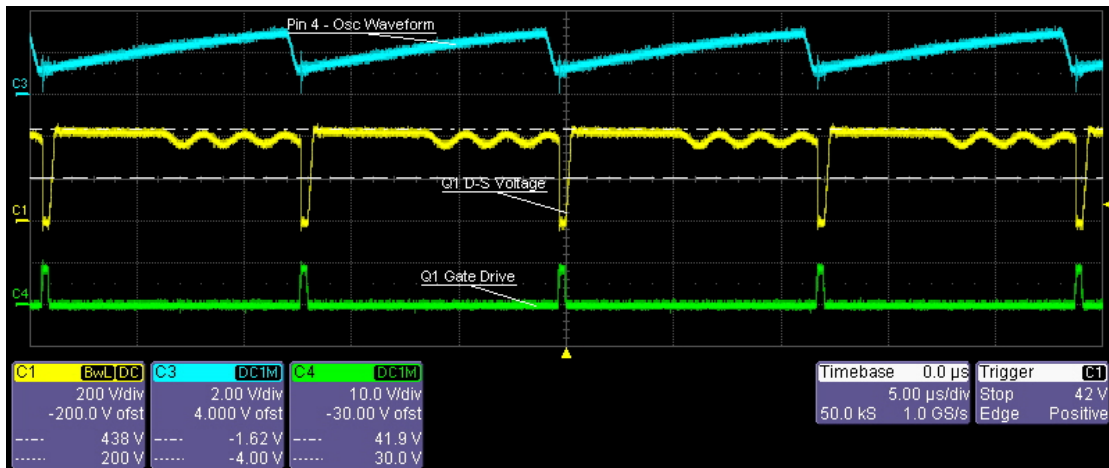


Figure 10: Steady State Waveforms at 270Vac with One LED at 350mA

4.4 Start up

The startup profile is captured at 90Vac and 270Vac with a load of three LEDs operating at a current of 1A.

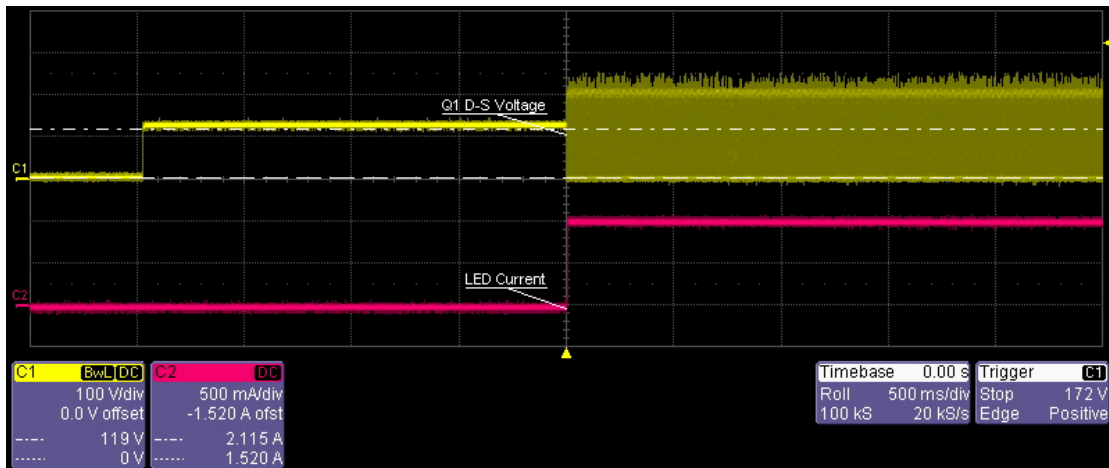


Figure 11: Startup Profile at 90 Vac with Three LEDs at 1A

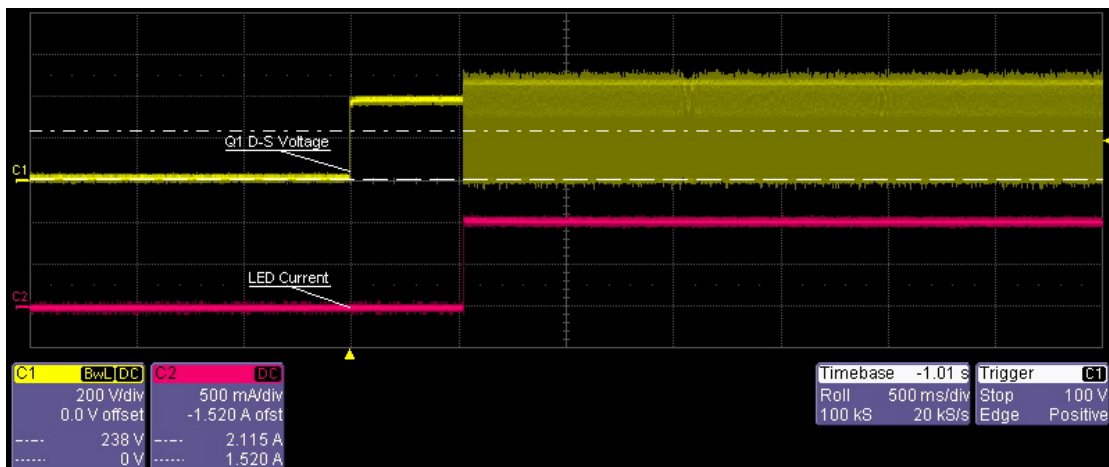


Figure 12: Startup Profile at 270Vac with Three LEDs at 1A

Warning and Disclaimer:

This Evaluation Board may employ high voltages so appropriate safety precautions should be used when operating this board. Replace components on the Evaluation Board only with those parts shown on the parts list in the User's Guide. Contact an authorized Fairchild representative with any questions.

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