FAIRCHILD™

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FL5160 IGBT and MOSFET AC Phase Cut Dimmer Controller

LED Lighting

May, 2016

Agenda

- FL5160 Product Development Background
- Update FL5160 Status and UL1472 ground leakage spec
  - Demonstrate Silicon
- Summary and discussion
- Appendix

FL5160 Product Development

FL5150 & FL5160 IGBT / MOSFET AC Phase-Cut Dimmer Controller

- Fairchild has a new Dimmer Controller IC in development to address new lighting requirements for non-resistive loads: LED products
- For North America, the FL5160 can make use of the green safety wire in a wall-box to detect zero crossing for flicker reduction. Fairchild requested to Underwriters Laboratories to allow a small (<500μA) ground leakage current for UL1472: The UL1472 standard was updated in September 2015.

FL5160 Product Update

UL Standard for Safety for Solid-State Dimming Controls, UL 1472

Second Edition, Dated September 25, 2015

Summary of Topics

This second edition of ANSI/UL 1472 includes the following:

1. ***Addition of requirements for field replaceable actuator assemblies***

2. ***Revising and adding requirements with respect to wall-box dimmer switches for use with LED lamp with integral driver light source***

3. ***Addition of requirements for ground leakage current***

FL5160 Product Update

4.6.5 Circuitry shall be arranged such that an equipment-grounding/bonding connection or conductor, or an equipment-bonding connection or conductor does not carry current.

Exception: A current not exceeding 0.5 mA conducted through an equipment-grounding or the equipment-bonding conductor or connection, when measured in accordance with 5.14, is not prohibited if all of the following are met:

1) The dimmer is not provided with a grounded (neutral) connection or conductor;

2) The leakage current is limited by two independent means listed below, a) to d). Each independent means shall be capable of limiting the available leakage current to not more than 0.5 mA;

a) Metal film, carbon film, wire wound, and metal glazed resistors;

b) Metallized polyester film capacitors;

c) Antenna-coupling capacitors, and line-by-pass capacitors that comply with the Standard for Capacitors and Suppressors for Radio- and Television-Type Appliances, UL 1414; and

d) Other components, if investigated and found acceptable for the application.

3) The device is marked in accordance with 7.2.6.

The ground leakage current spec was added in section 4.6.5

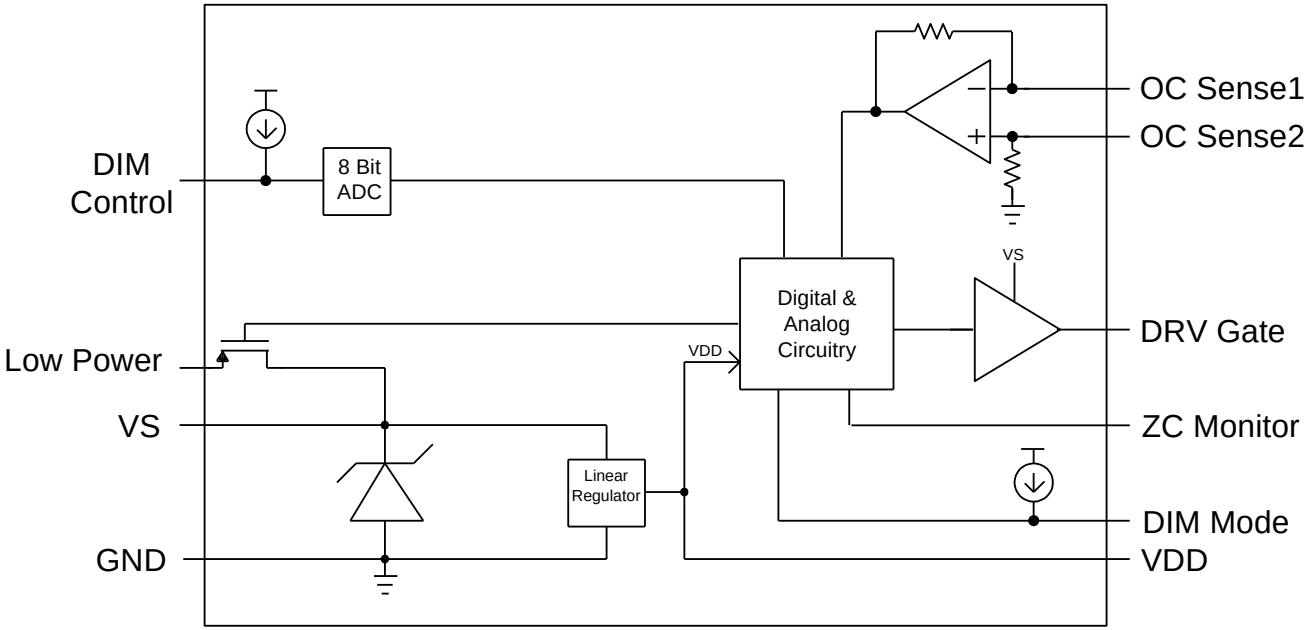
FL5160 Product Update

We plan to production release the FL5160 (60Hz) and FL5150 (50Hz) Dimmer controller products next month
We have plastic samples and a demo board for evaluation

The FL5160 features include:

- Selectable Trailing or leading edge phase cut dimming
- 8 Bit ADC with ~226 dimming pulse widths
- Line Hot or Earth GND ZC detection
- Over current and temperature protection
- Soft start
- Automatically Max Gate Pulse Width control(Auto Max)
- Force 100% duty cycle for 3-wire applications
- Min & max ZC window comparator
- Low power mode
- SOIC10 Package
- Minimum External components

FL5160 Product Update



Brief Description for the FL5160 circuitry:

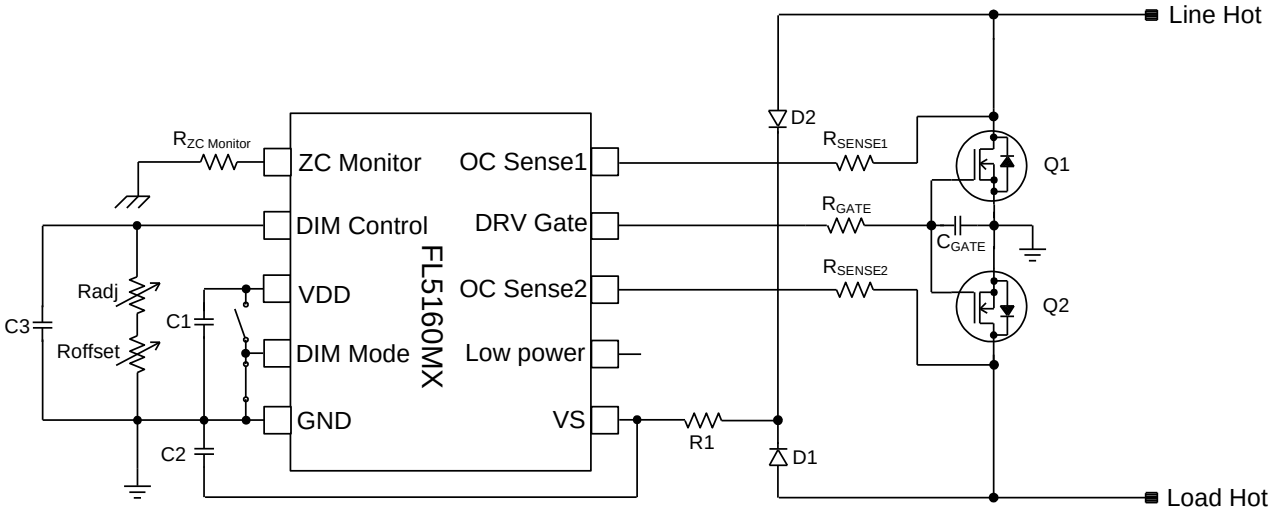
A 17V shunt regulator generates the bias for the gate drive and a 5V linear regulator provides bias for the CMOS digital logic.

There is a 10uA current source for the DIM Control pin. A 0 to 250KΩ adjustable resistor connected to this pin provides for min and max PW dimming via an 8 Bit ADC

At POR the DIM Mode pin is checked and if low, TE mode is selected (~75ms). If this pin is connected to VDD, LE mode is selected. Also at start up the ZC Monitor pin's phase is compared to the OC Sense 1 pin's phase and the appropriate internal circuitry is selected for Earth or Line Hot ZC detection.

The DIFF AMP monitors the voltage across the drains (collectors) of Q1 & Q2 and provides for over current and temperature protection

FL5160 Product Update



FL5160 600W 120VAC Typical 2-wire Application (with on/off air gap switch)

Typical Values:

U1: FL5160MX
Q1&2: FDPF33N25T
D1&2: 400V
R1: 10KΩ
$R_{SENSE1\&2}$: 1MΩ
$R_{ZC\ Monitor}$: 1MΩ
R_{Gate}: 1kΩ
R_{ADJ}: 0 to 250KΩ
C1: 100nF (6.3V)
C2: 2.5μF (25V)
C3: 100nF (6.3V)

Minimum number of components:

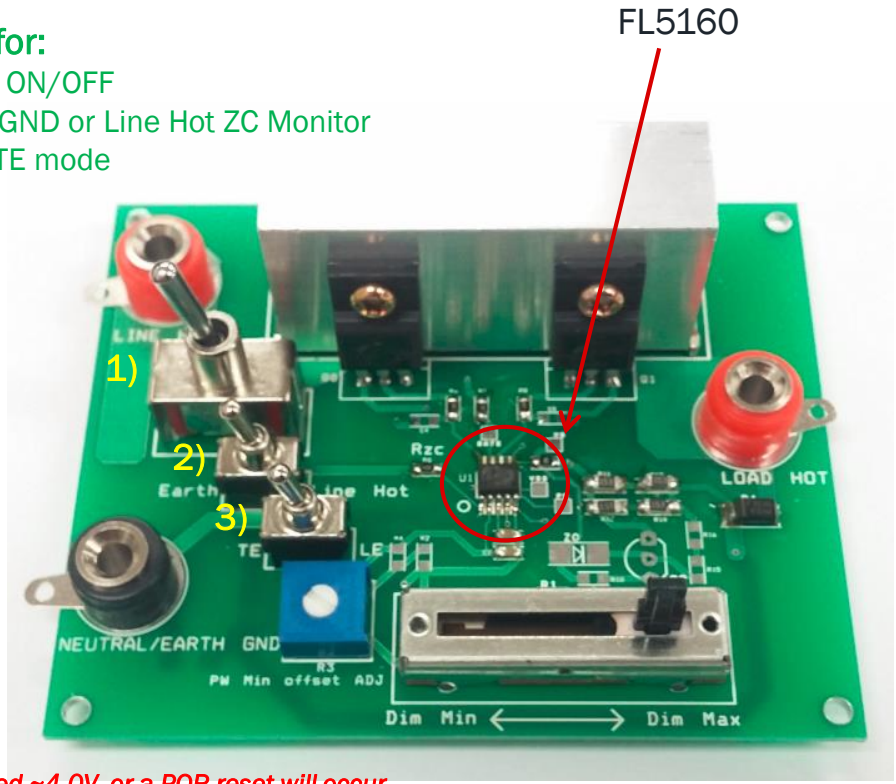
1) Low BOM cost
2) Space savings
3) Higher reliability
4) No high value capacitors

10-SOIC FL5160 demo board, rev1

U1: FL5160
C0: 100nF (DIM Control)
C1: 100nF (VDD)
C2: 2.0uF, C3: 470nF (VS)
C8: 22nF (Gate)
C4 & C5: Not used
C7: Csnub Not used (No Lsnub)
Q0 & Q1: FDPF33N25T (33A, 250V MOSFET)
Q2: Not used
D1 & D2: RS1M
R0: 1Mohms (ZC Monitor)
R6=R8: 1Mohms (OC Sense1 & 2)
R11-14: 10Kohms (VS), (10K//10K + 10K//10K=3216 1/4W)
R1: Max. 250Kohms, slider resistor for DIM Control
R3: Max. 100Kohms, pot resistor for DIM Control
R5: 1kohms (VDD)
R7: 1kohms (Gate)
R9: 0ohm (VS)
R2 & R4: Not used
R10: Not used
R15-16: Not used

Switches for:

1) Power ON/OFF
2) Earth GND or Line Hot ZC Monitor
3) LE or TE mode

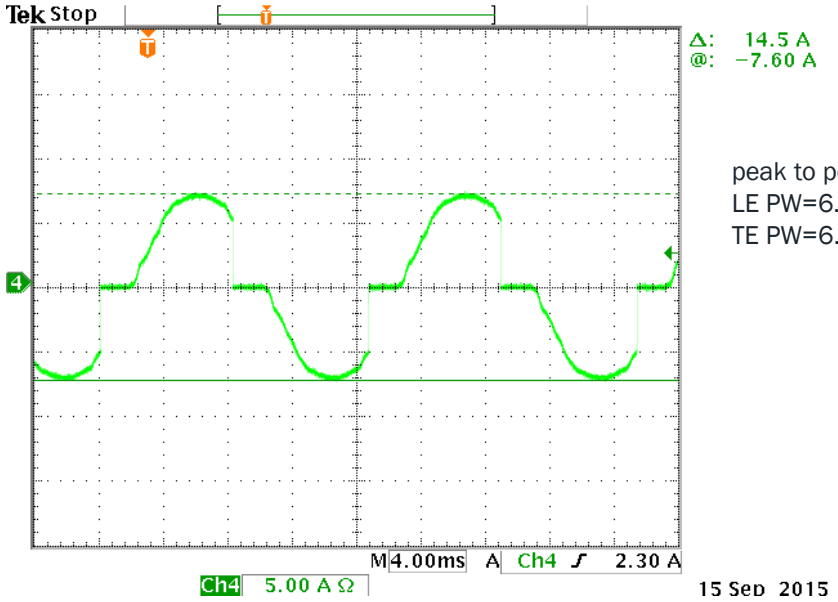


**Note: For a 2-wire application, the DIM Control pin voltage should not exceed ~4.0V or a POR reset will occur*

FL5160 demo board

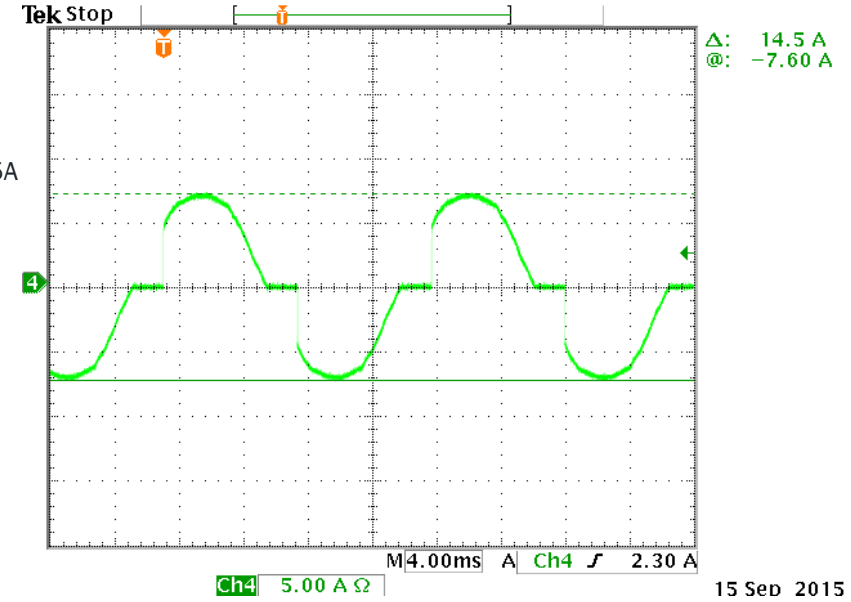
Waveforms for LE/TE for selected loads

600W Incandescent Trailing Edge



peak to peak current: 14.5A
LE PW=6.5ms
TE PW=6.4ms

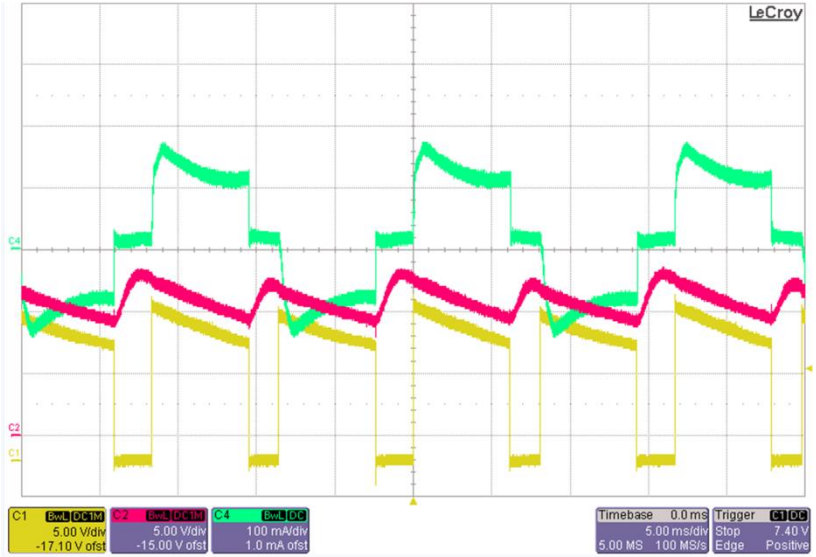
600W Incandescent Leading Edge



FL5160 demo board – 2 wire

Waveforms for LE/TE for selected loads

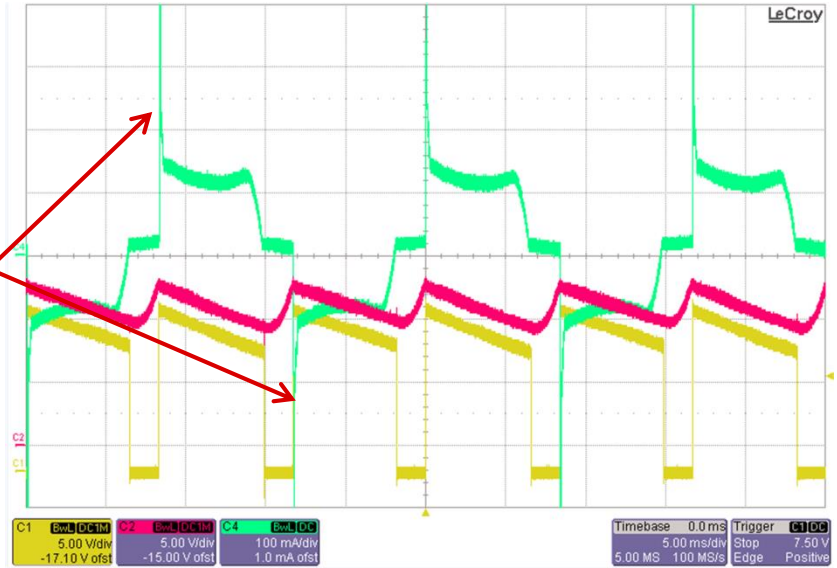
Trailing Edge, GE LED



C1[DRV] C2[VS] C4[I_{LOAD}]

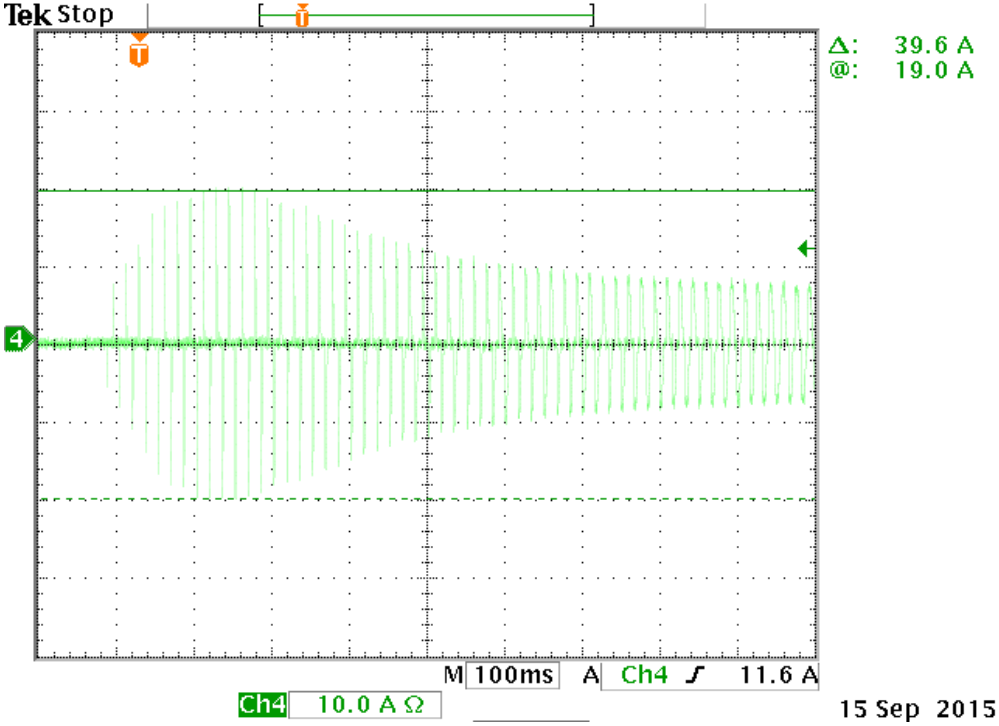
Note high current spikes

Leading Edge, GE LED



16 pin FL5160 demo board

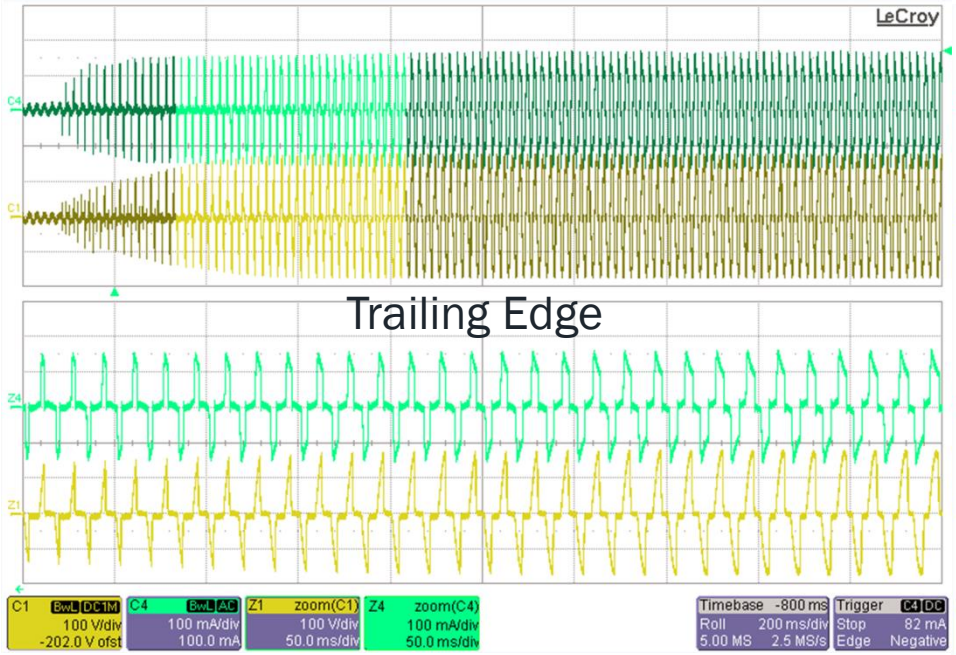
Start Up, 600W Incandescent Leading Edge

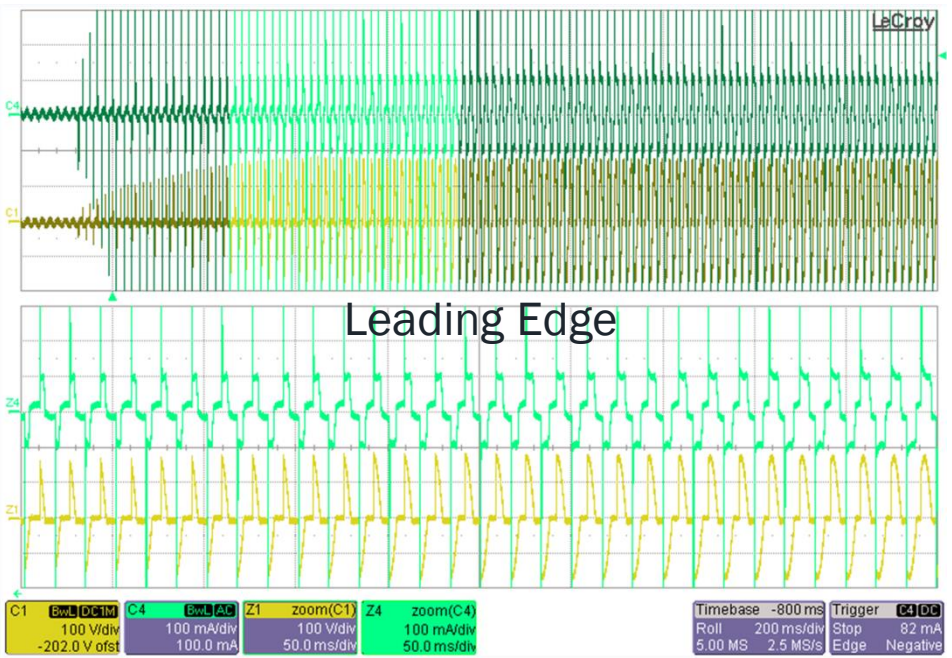


Note: peak to peak current: 39.4A

FL5160 demo board – 2 wire

Start-up with GE LED

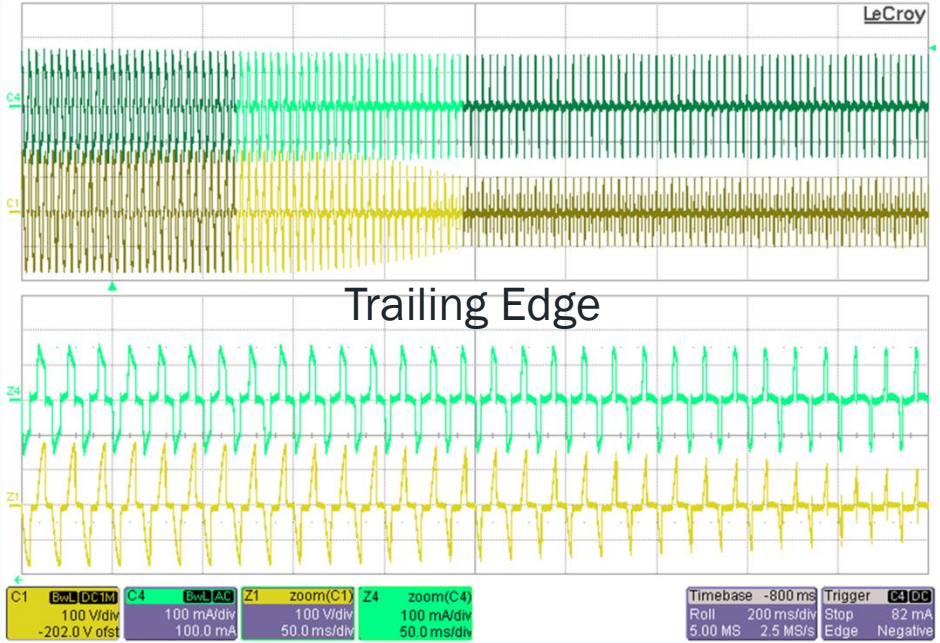


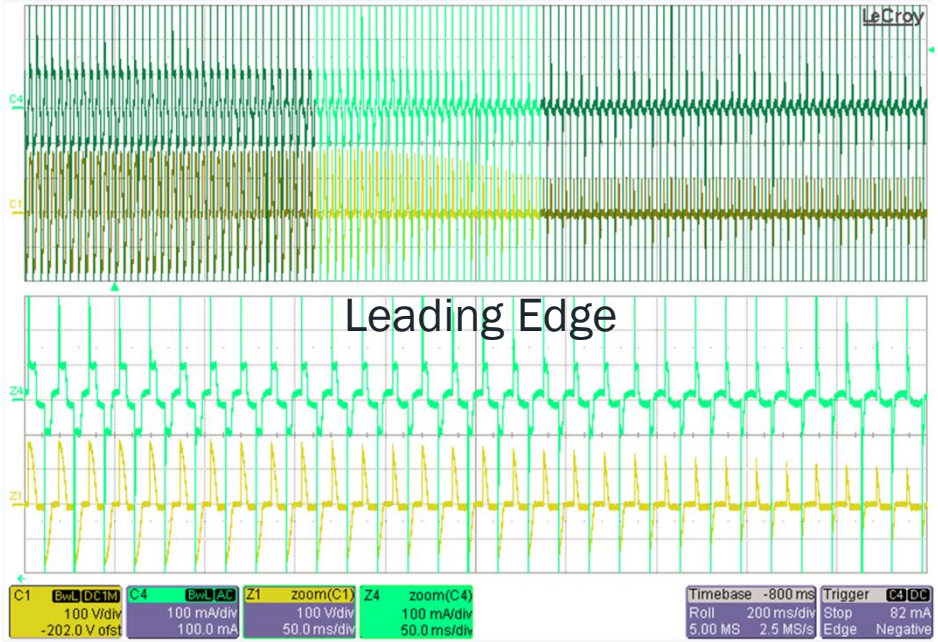


C1[$V_{LOADHOT}$] C4[I_{LOAD}]

FL5160 demo board – 2 wire

Turn-off with GE LED





C1[$V_{LOADHOT}$] C4[I_{LOAD}]

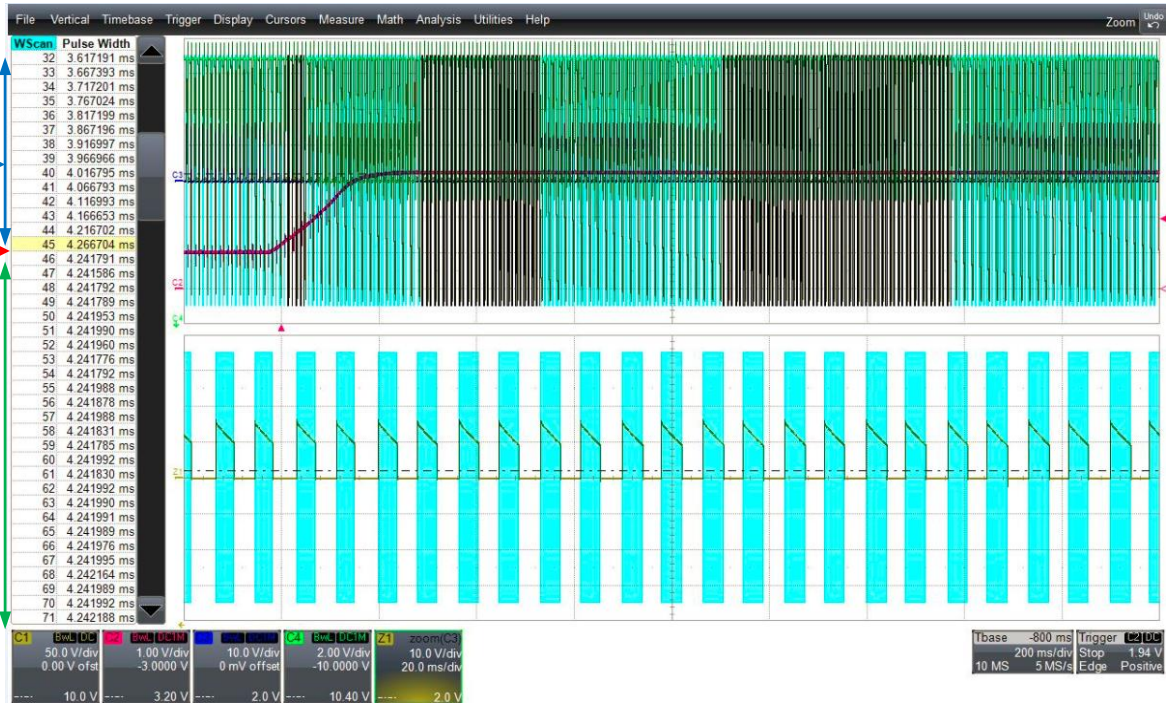
FL5160 demo board – 2 wire

AUTO MAX Control – TE mode

50us increment

25us reduction

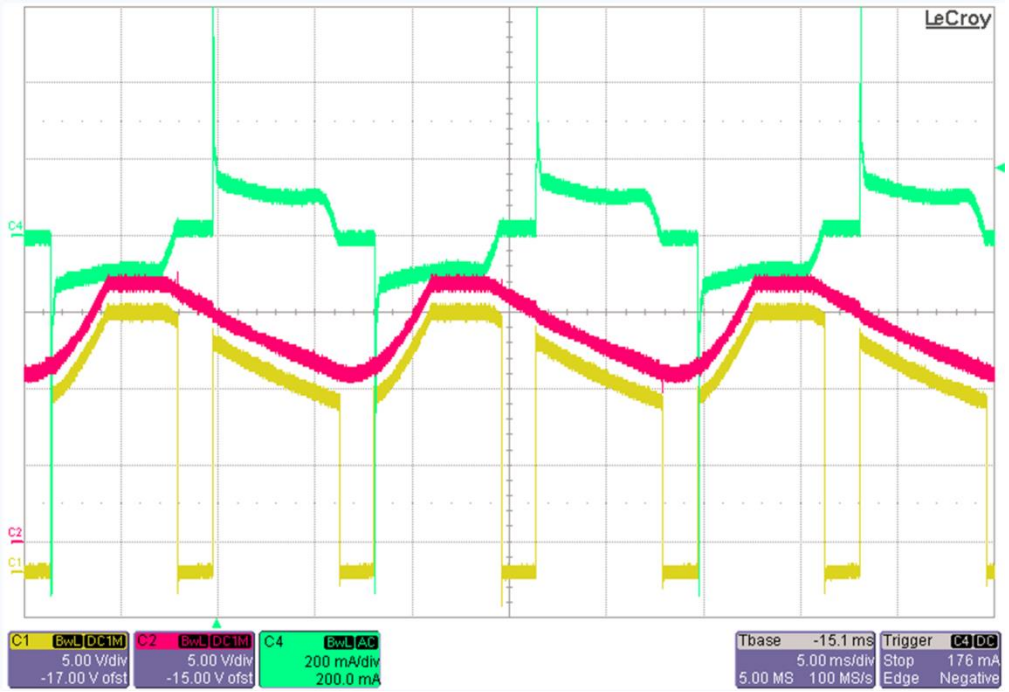
Steady state
(No change)



C1[$V_{LOAD\ HOT}$]C2[PWC]C3[DRV]C4[VS]

FL5160 demo board – 3 wire

Steady State Waveform at LE mode with GE LED

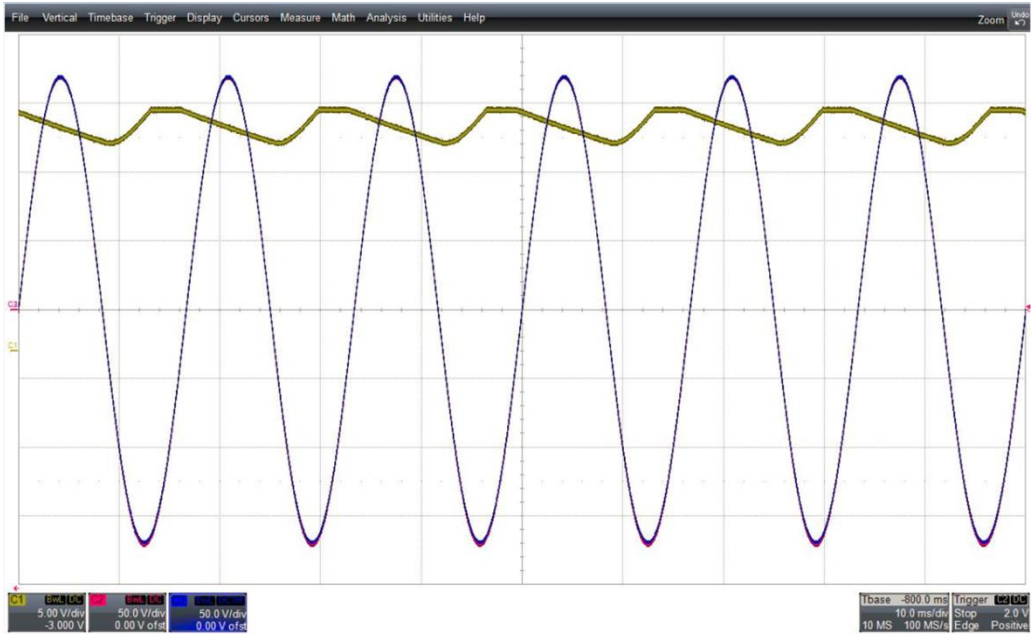


C1[DRV] C2[VS] C4[I_{LOAD}]

VS charged every negative half cycle and discharged for every positive cycle

FL5160 demo board – 3 wire

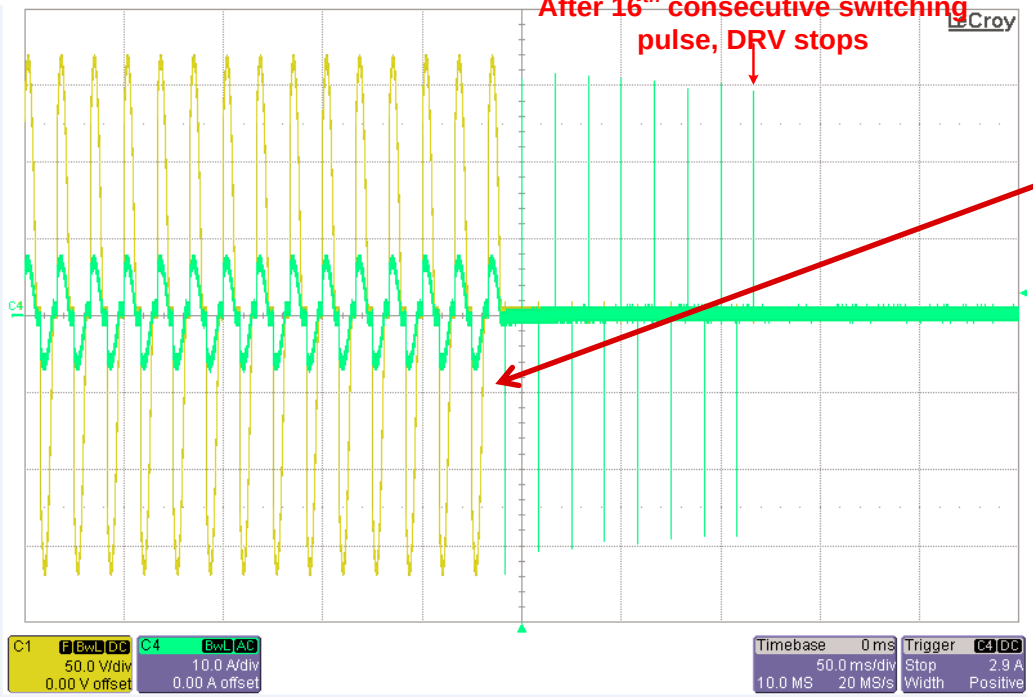
100% Duty control – TE mode



C1[DRV] C2[$V_{LINE\ HOT}$] C3[$V_{LOAD\ HOT}$]

FL5160 demo board – 3 wire

Over Current Protection



C1[$V_{LOAD\ HOT}$]C4[I_{LOAD}]

OC triggered after a load increased from 600 to 900W

FL5160 demo board summary

We have tested many different types of loads to demonstrate the FL5160 performance :

EcoSmart, Cree, GE, Sylvania (Osram), Philips, Lithonia, Feit and 900W incandescent loads

With all of our testing, no snubber circuit was used (no L or C).

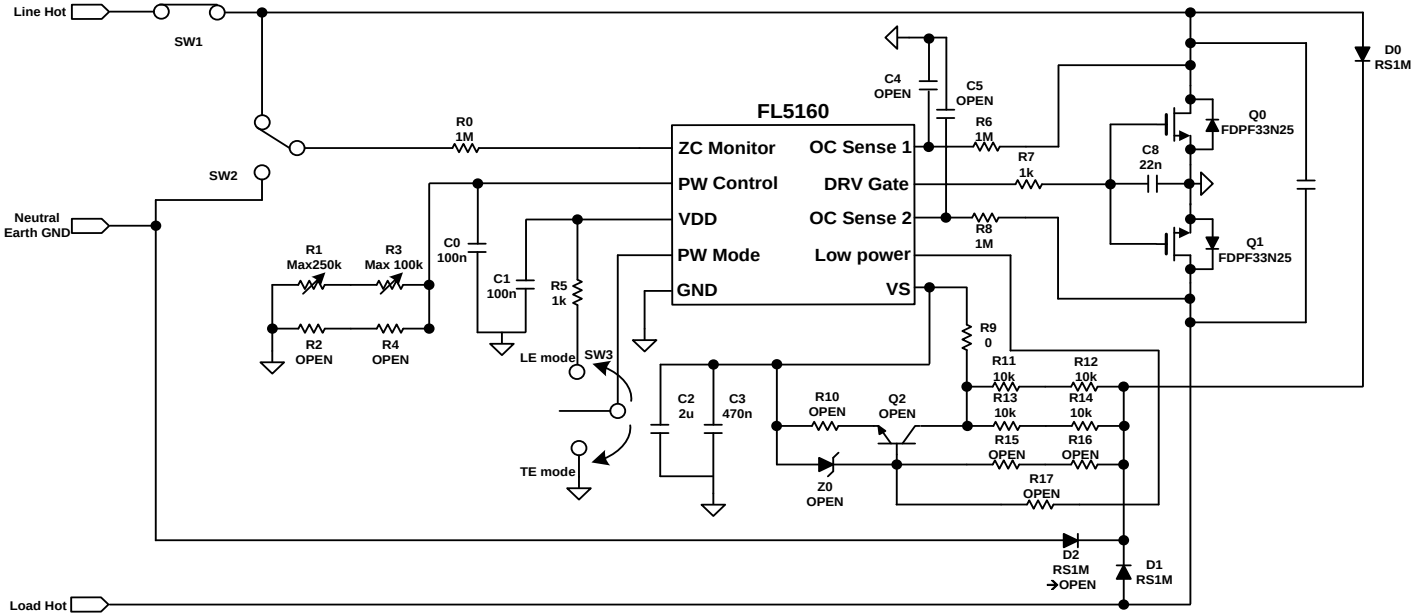
No component damage was observed

Demo board testing summary:

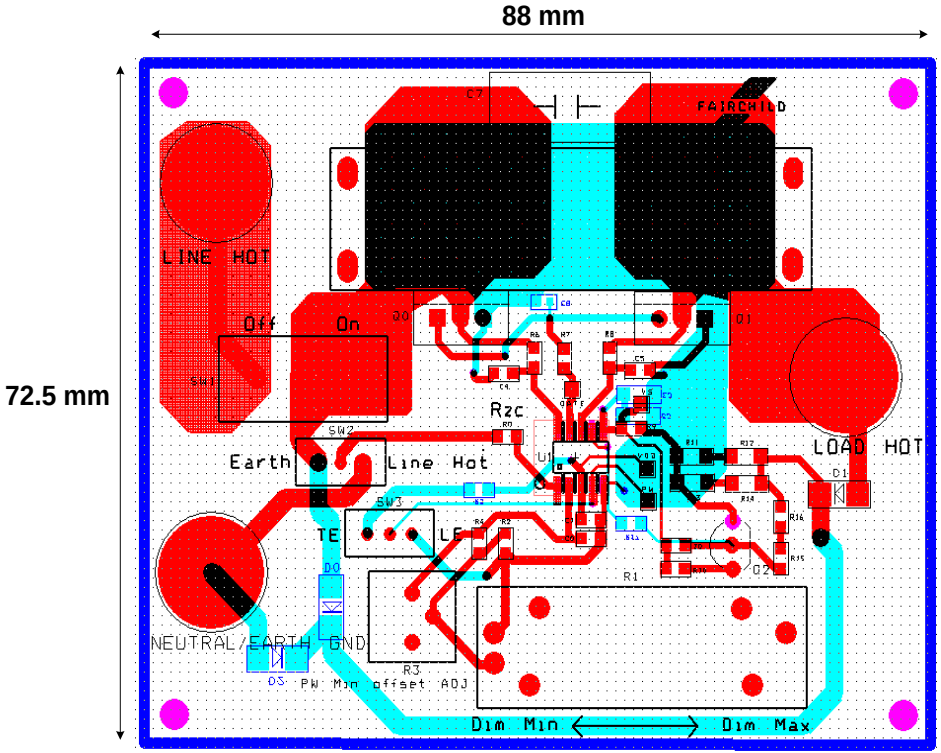
- *The FL5160 will provide for a low cost flicker free universal dimmer product when the earth ground signal is used for the zero cross reference*

THANK YOU

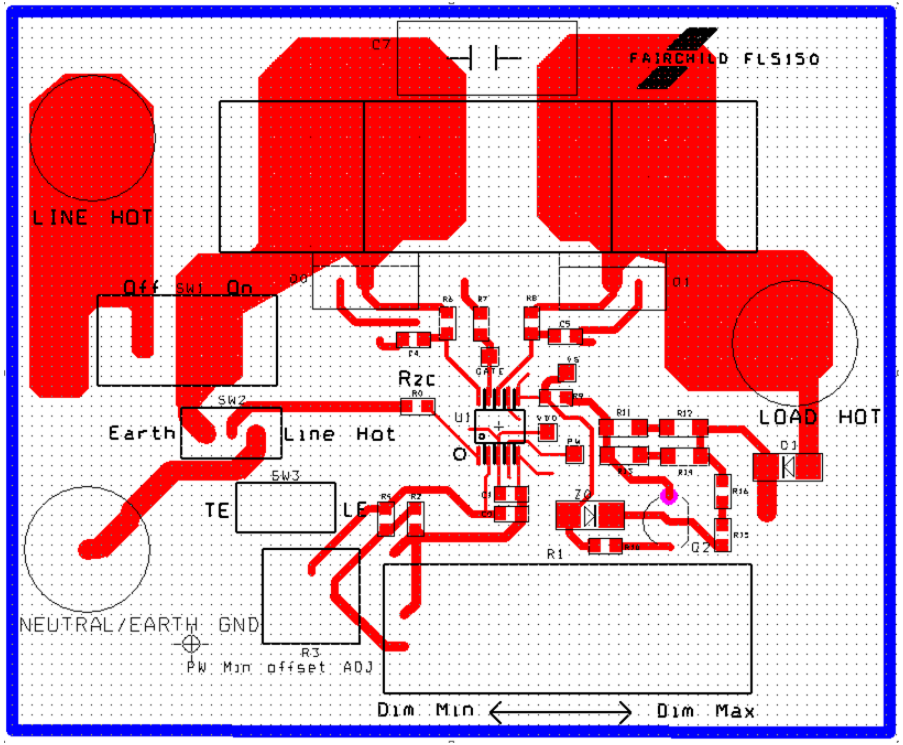
Appendix: Schematic For FL5160



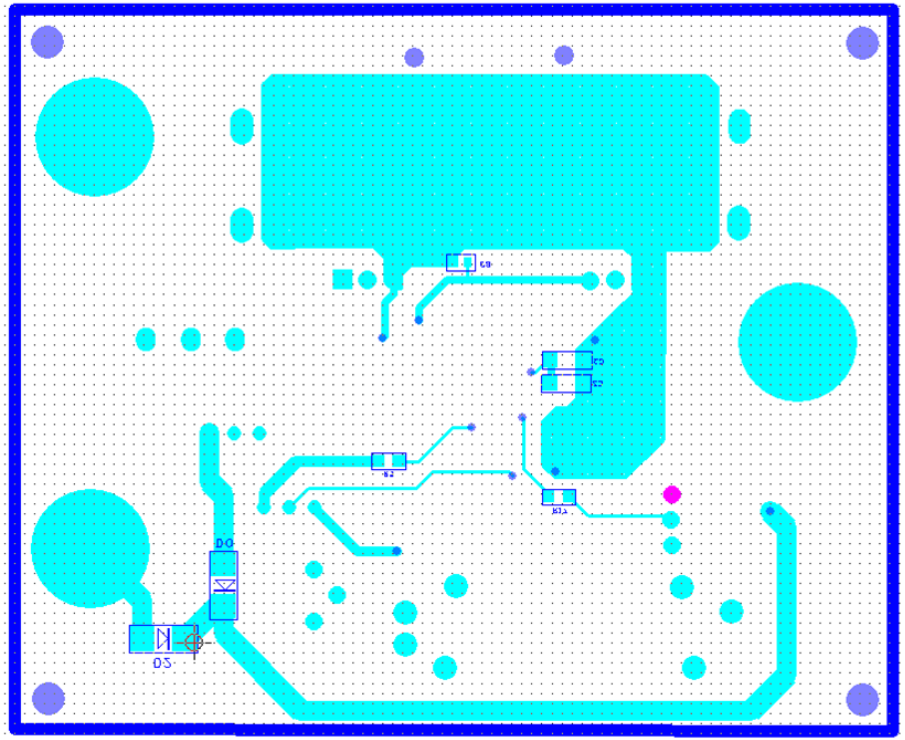
Appendix: PCB Layout For TO-220F + 10 PIN FL5160 – Top Layer & Bottom Layer



Appendix: PCB Layout For TO-220F + 10 PIN FL5160 – Top Layer



Appendix: PCB Layout For TO-220F + 10 PIN FL5160 – Bottom Layer



Appendix: FL5160 SOIC10 Package

Physical Dimensions

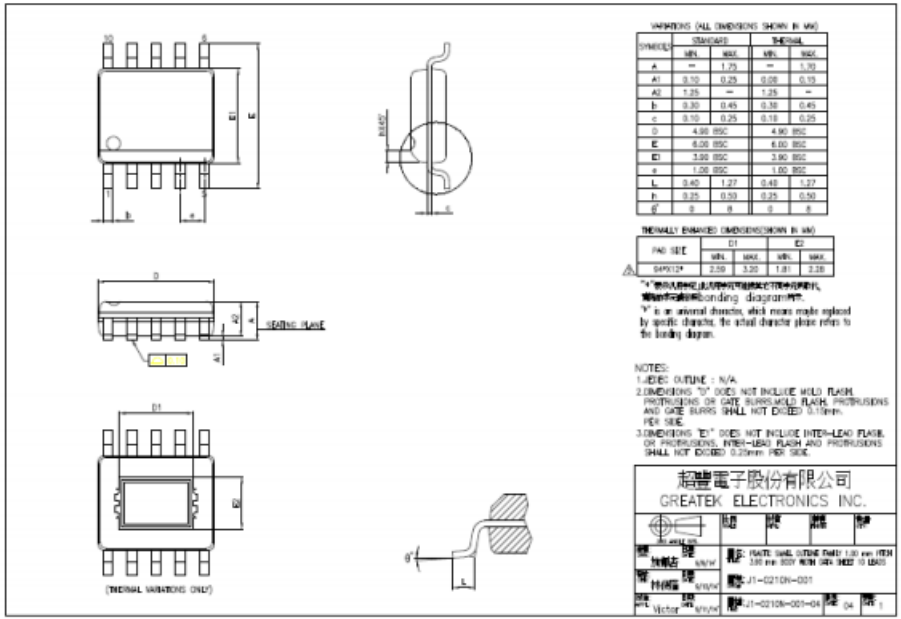


Figure 7 10-Lead Plastic SOIC Package