

# IRPLDIM4E

---

## Miniature Dimmable 26W Ballast Using IRS2530D *DIM8*<sup>TM</sup> Control IC

### Table of Contents

|  | <b>Page</b> |
|--|-------------|
| 1. Overview .....  | 2           |
| 2. Features .....  | 2           |
| 3. Electrical Characteristics .....                            | 3           |
| 4. Fault Protection Characteristics .....                      | 3           |
| 5. IRS2530D <i>DIM8</i> <sup>TM</sup> Ballast Control IC ..... | 4           |
| 6. Circuit Description .....                                   | 4           |
| 7. Circuit Schematics .....                                    | 5           |
| 8. Bill of Materials .....                                     | 6           |
| 9. Functional Description .....                                | 7           |
| 10. Fault Conditions .....                                     | 10          |
| 11. PCB Layout and Component Placement .....                   | 14          |
| 12. Inductor Specifications .....                              | 17          |



### 3. Electrical Characteristics

| Parameter                | Units    | Dimming Level | Value            |
|--------------------------|----------|---------------|------------------|
| Lamp Type                |          |               | 26W CFL          |
| Input Power              | [W]      | 100%          | 25               |
|                          |          | 10%           | 9                |
| Input Current            | [mArms]  | 100%          | 180              |
|                          |          | 10%           | 78               |
| Lamp Running Voltage     | [Vpp]    | 100%          | 320 <sup>†</sup> |
|                          |          | 10%           | 480              |
| Lamp Running Current     | [mArms]  | 100%          | 271              |
|                          |          | 10%           | 26               |
| Start Frequency          | [kHz]    |               | 115              |
| Run Frequency            | [kHz]    | 100%          | 42               |
|                          |          | 10%           | 68               |
| Preheat Time             | [s]      |               | 1                |
| Input AC Voltage Range   | [VACrms] |               | 200 - 250        |
| Ballast turn-off voltage | [VACrms] |               | 85               |

TABLE 3.1: Ballast Parameters.

† The lamp running voltage at 100% dimming level is not perfectly sinusoidal and has some distortion.

### 4. Fault Protection Characteristics

| Fault                 | Protection                | Ballast            | Restart Operation     |
|-----------------------|---------------------------|--------------------|-----------------------|
| Brown-out             | Non-ZVS                   | Increase frequency | Line voltage increase |
| Upper filament broken | Crest Factor Over Current | Deactivates        | Lamp exchange         |
| Lower filament broken | Crest Factor Over Current | Deactivates        | Lamp exchange         |
| Lamp removed          | Crest Factor Over Current | Deactivates        | Lamp inserted         |
| Failure to ignite     | VVCOFLT+                  | Deactivates        | Lamp exchange         |
| No lamp               | VLOSD-                    | Does not start     | Lamp inserted         |
| End of life           | Crest Factor Over Current | Deactivates        | Lamp exchange         |

TABLE 4.1: Fault Protections Characteristics.

## 5. IRS2530D DIM8™ Ballast Control IC

The IRS2530D is an application specific solution for dimming CFL and TL lamps in CFL or matchbox (small size ballasts) applications. It integrates all of the necessary functions for preheat, ignition and dimming control of the lamp, plus lamp fault protection, low AC-line protection, lamp exchange auto-restart, and a 600V half-bridge driver into a standard SO8 or DIP8 package.

The IRS2530D includes adaptive zero-voltage switching, non-zero voltage switching (ZVS) protection, as well as an integrated 600V bootstrap MOSFET. The heart of this IC is a voltage-controlled oscillator (VCO) with a dimming reference/feedback input. One of the biggest advantages of the IRS2530D is that it uses the VS pin (the mid-point of the half-bridge) for over-current protection and to detect non-ZVS conditions. The IRS2530D uses the RDSon of the low-side half-bridge MOSFET for current sensing each cycle when the low-side MOSFET is on. An internal 600V MOSFET connects the VS pin to the VS-sensing circuitry and allows for the VS pin to be accurately measured during the time when pin LO is high, while withstanding the high DC bus voltage during the other portion of the switching cycle when the high-side MOSFET is turned on. This eliminates the need for an external, precision current sensing resistor that is typically used to detect over-current. Please refer to the IRS2530D datasheet for further information including electrical parameters, a state diagram and a complete functional description.

As a result of the IRS2530D features, the IRPLDIM4E Reference Design is a complete dimming ballast solution that includes lamp fault protection, low AC line protection, lamp exchange auto-restart, and reduces component count and ballast size.

## 6. Circuit Description

The schematic for IRPLDIM4E is shown in Figure 7.1. The bill of materials with the component values is shown in Table 8.1.

The ballast incorporates a fuse, input rectifier, EMI filter, bus capacitor, half-bridge, dimming control and output stage. The output stage is a series-L, parallel-RC resonant circuit consisting of an inductor (LRES), capacitor (CRES), and lamp. The AC line input voltage is rectified to provide a bus voltage of approximately 300VDC. The start-up resistors, RVCC1 and RVCC2, are sized such that they supply the micro-power current during under-voltage lockout (UVLO) mode and determine the AC line voltage where the ballast turns-on. When VCC exceeds the startup threshold (VCCUV+), the IRS2530D begins to oscillate and the charge pump circuit (CVS, DCP1 and DCP2) supplies the current to VCC while maintaining the internal VCC zener clamp at 15.6V.

The IRS2530D controls the frequency of the half-bridge for satisfying the lamp operating modes. These include lamp preheat, lamp ignition, dimming, low AC line protection and lamp/ballast fault protection.

### 7. Circuit Schematic

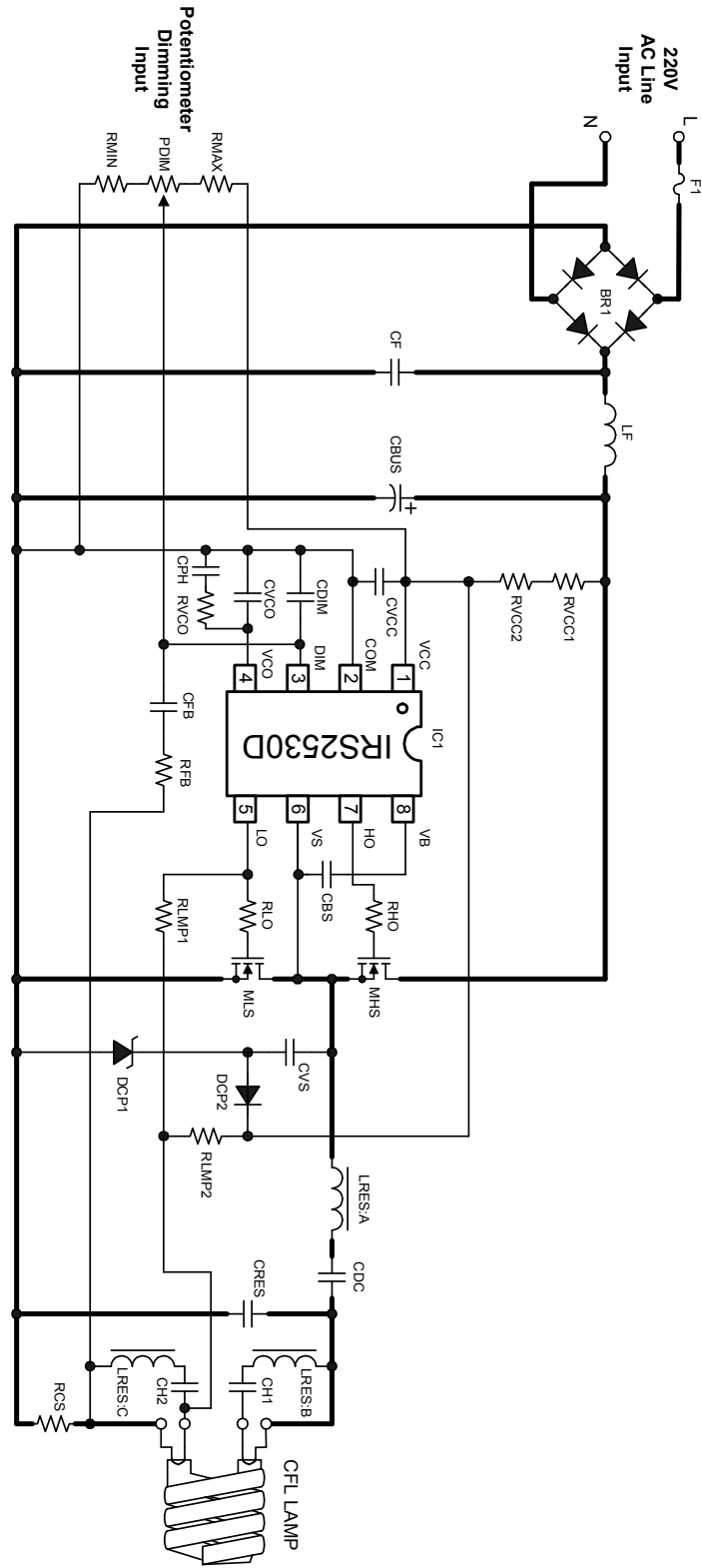


Figure 7.1: IRPLDIM4E Circuit Schematic

## 8. Bill of Materials

| Item #       | Qty       | Manufacturer            | Part Number                         | Description   | Reference    |
|--------------|-----------|-------------------------|-------------------------------------|---|--------------|
| 1            | 1         | Digikey<br>Diodes, Inc. | RH06DICT-ND<br>RHO6-T               | Bridge Rectifier, 600V, 0.5A MiniDip                  | BR1          |
| 2            | 1         | Digikey<br>Vishay       | PPC.47BCT-ND<br>NFR25H0004707JR500  | Resistor, 0.47R, 1/2W                                 | F1           |
| 3            | 1         | Digikey<br>Epcos        | M8301-ND<br>5800-102-RC             | RF Chokes 1mH 200mA                                   | LF           |
| 4            | 2         | Wima                    | MKS2 Series                         | Capacitor, 47nF, 400V                                 | CF, CDC      |
| 5            | 1         | Digikey<br>Panasonic    | P5931-ND<br>EEU-EB2V100             | Capacitor, 10µF, 350VDC, 105C                         | CBUS         |
| 6            | 2         | Digikey<br>Panasonic    | PCC104BCT-ND<br>ECJ-3VB1H104K       | Capacitor, 0.1µF, 50V, 1206                           | CBS, CFB     |
| 7            | 2         | Digikey<br>Panasonic    | PCC1886CT-ND<br>ECJ-3VB1E184K       | Capacitor, 0.18µF, 25V, 1206                          | CH1, CH2     |
| 8            | 1         | Digikey<br>Yageo        | 311-1171-1-ND<br>CC1206KRX7R9BB222  | Capacitor, 2.2nF, 50V, 1206                           | CVCO         |
| 9            | 1         | Digikey<br>Panasonic    | PCC1892CT-ND<br>ECJ-3YBIE684K       | Capacitor, 0.68µF, 25V, 1206                          | CPH          |
| 10           | 1         | Digikey<br>Panasonic    | PCC1882CT-ND<br>ECJ-3YB1C105K       | Capacitor, 1µF, 16V, 1206                             | CVCC         |
| 11           | 1         | Digikey<br>Yageo        | 311-1174-1-ND<br>CC1206KRX7R9BB103  | Capacitor, 10nF, 50V, 1206                            | CDIM         |
| 12           | 1         | Digikey<br>Panasonic    | P9542-ND<br>ECK-A3A102KBP           | Capacitor, 1nF, 1KV, Ceramic disk                     | CVS          |
| 13           | 1         | Wima<br>TAW             | MKP-10 RM15MM<br>MKP 472K1K6        | Polypropylene Capacitor,<br>4.7nF/1.6KV, 10%, RM=15mm | CRES         |
| 14           | 1         | IR                      | IRS2530D                            | Dimming Ballast Control IC                            | IC1          |
| 15           | 1         | Vogt                    | IR IL 070 503 11 02                 | Ballast Resonant Inductor EF20,<br>2.3mH              | LRES         |
| 16           | 2         | Digikey/Vishay          | IRFU320                             | Transistor, MOSFET, 400V                              | MHS, MLS     |
| 17           | 2         | Digikey<br>Panasonic    | P360KECT-ND<br>ERJ-8GEYJ364V        | Resistor, 360K, 1206                                  | RVCC1, RVCC2 |
| 18           | 1         | Digikey<br>Panasonic    | PPC7.5W-1CT-ND<br>5073NW7R500J12AFX | Resistor, 7.5 Ohm, 5%, 1 W, Axial                     | RCS          |
| 19           | 1         | Digikey<br>Panasonic    | P220KECT-ND<br>ERJ-8GEYJ224V        | Resistor, 220K, 1206                                  | RLMP1        |
| 20           | 1         | Digikey<br>Panasonic    | P470KECT-ND<br>ERY-8GEYJ474V        | Resistor, 470K, 1206                                  | RLMP2        |
| 21           | 1         | Digikey<br>Panasonic    | RHM430FCT-ND<br>MCR18EZH4300        | Resistor, 430 Ohm, 1%, 1206                           | RMIN         |
| 22           | 1         | Digikey<br>Panasonic    | P200KFCT-ND<br>ERJ-8ENF2003V        | Resistor, 200K, 1%, 1206                              | RMAX         |
| 23           | 1         | Digikey<br>Panasonic    | P1.0KALCT-ND<br>ERJ-P08J102V        | Resistor, 1K, 1206                                    | RFB          |
| 24           | 1         | Digikey<br>Yageo        | 311-1.5KERCT-ND<br>RC1206JR-071K5L  | Resistor, 1.5K, 1206                                  | RVCO         |
| 25           | 2         | Digikey<br>Panasonic    | P10ECT-ND<br>ERJ-8GEYJ100V          | Resistor, 10 Ohm, 1206                                | RHO, RLO     |
| 26           | 1         | Digikey<br>Bourns       | 3386P-103LF-ND<br>3386P-1-103LF     | Pot, 10K, Single turn                                 | PDIM         |
| 27           | 1         | Digikey<br>Diodes, Inc. | LL4148DICT-ND                       | Diode, 1N4148 SMT DL35                                | DCP2         |
| 28           | 1         | Digikey<br>Diodes, Inc. | ZMM5248BDICT-ND<br>ZMM2548B-7       | Zener Diode, 18V, 500mV, SMT                          | DCP1         |
| 29           | 1         |                         |                                     | Wire Jumper   | J1           |
| 30           | 1         | WAGO                    | 235-202                             | Connector, 2 terminal                                 | X1           |
| 31           | 1         | WAGO                    | 235-204                             | Connector, 4 terminal                                 | X2           |
| 32           | 1         | IR                      | IRPLDIM4E                           | PCB, Single Layer                                     |              |
| <b>Total</b> | <b>38</b> |                         |                                     |   |              |

**TABLE 8.1: IRPLDIM4E Bill of Materials. Lamp type: Spiral CFL 26W, Line Input Voltage: 200 - 250 VAC. Note: Different lamp types may require components with different values, voltage ratings and/or current ratings.**

## 9. Functional Description

When power is turned on, the IRS2530D first starts in Under Voltage Lockout (UVLO) mode. The UVLO mode is designed to maintain an ultra-low ( $<250\mu\text{A}$ ) supply current, and to guarantee that the IC is fully functional before the high- and low-side output (HO and LO) gate drivers are activated. During UVLO, HO is 'low', and VCO is pulled down to COM for resetting the starting frequency to the maximum. LO is open circuit, and is used as a shutdown/reset input function for automatically restarting the IC when a lamp has been removed and re-inserted.

Once VCC reaches the startup threshold ( $V_{CCUV+}$ ) and the LO pin is below  $V_{LOSD-}$  (lamp is inserted), the half-bridge FETs start to oscillate and the IC enters Preheat/Ignition Mode. At startup, VCO is 0V and the frequency starts at  $f_{MAX}$ . The frequency ramps down towards the resonant frequency of the high-Q ballast output stage, causing the lamp voltage to increase. During this time, the filaments of the lamp are pre-heated to their emission temperature to minimize the necessary ignition voltage and to increase lamp life. The voltage on pin VCO continues to increase and the frequency keeps decreasing until the lamp ignites. If the lamp ignites successfully, the IRS2530D enters the DIM mode. The resonant output stage transitions to a series-L, parallel RC circuit with the Q-value and operating point determined by the user dim level (Figure 9.1)

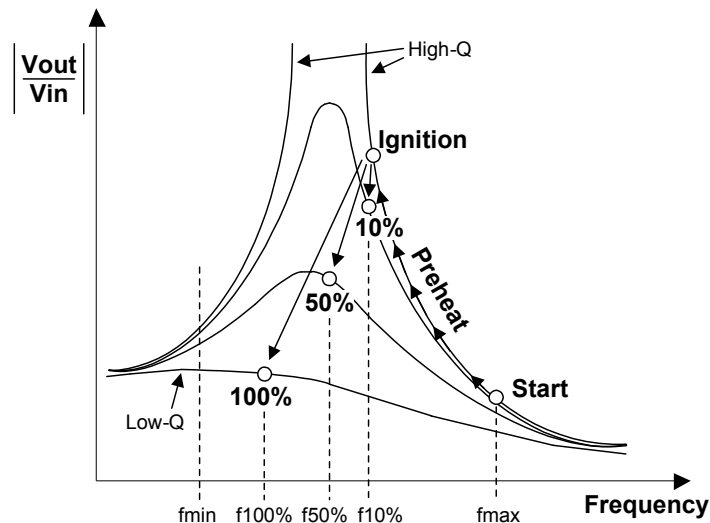


Figure 9.1: Resonant tank Bode plot with lamp dimming operating points

Figure 9.2 shows the VCO voltage, the voltage across the lamp, and the current through the lamp during Preheat, Ignition, and Dim mode for 100% dimming level. Figure 9.3 shows these waveforms for 10% dimming level.

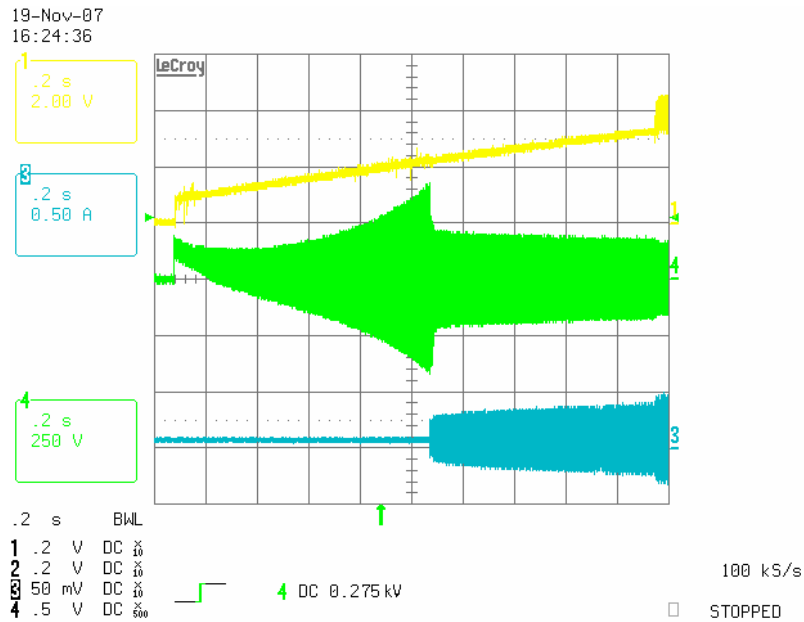


Figure 9.2: Preheat, Ignition, and Dim mode for 100% dimming level: CH1 is the VCO voltage, CH3 is the lamp current, and CH4 is the voltage across the lamp

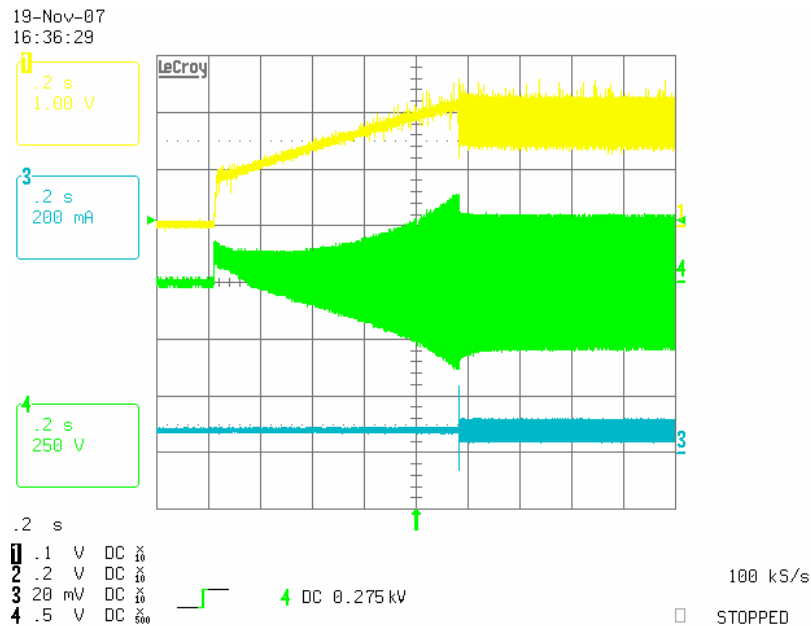


Figure 9.3: Preheat, Ignition, and Dim mode for 10% dimming level: CH1 is the VCO voltage, CH3 is the lamp current, and CH4 is the voltage across the lamp



Figure 9.4 shows the voltage at the DIM pin, the VS (half-bridge) voltage, and the voltage at the VCO pin during Dim Mode for 100% dimming level. Figure 9.5 shows these voltages for 10% dimming level.

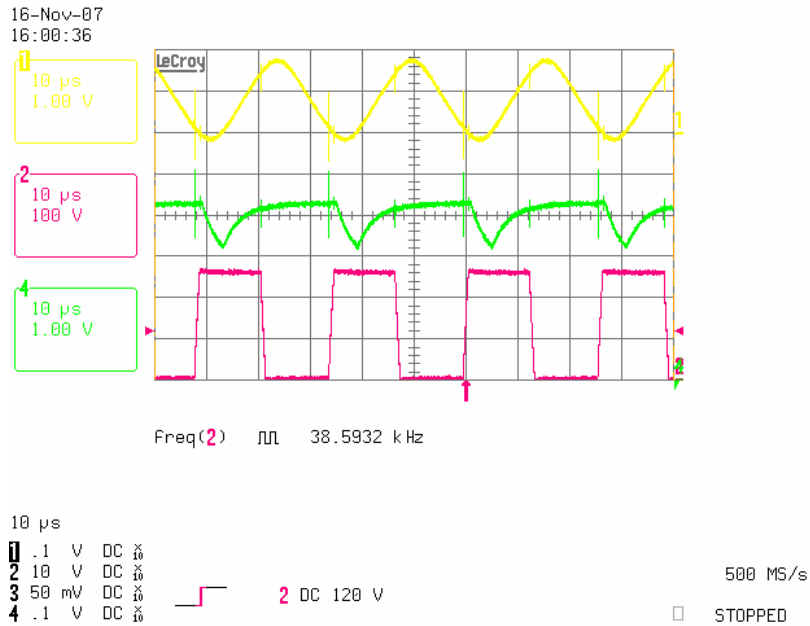


Figure 9.4: 100% dimming level waveforms: CH1 is the DIM voltage, CH2 is the voltage at VS pin, and CH4 is the VCO voltage

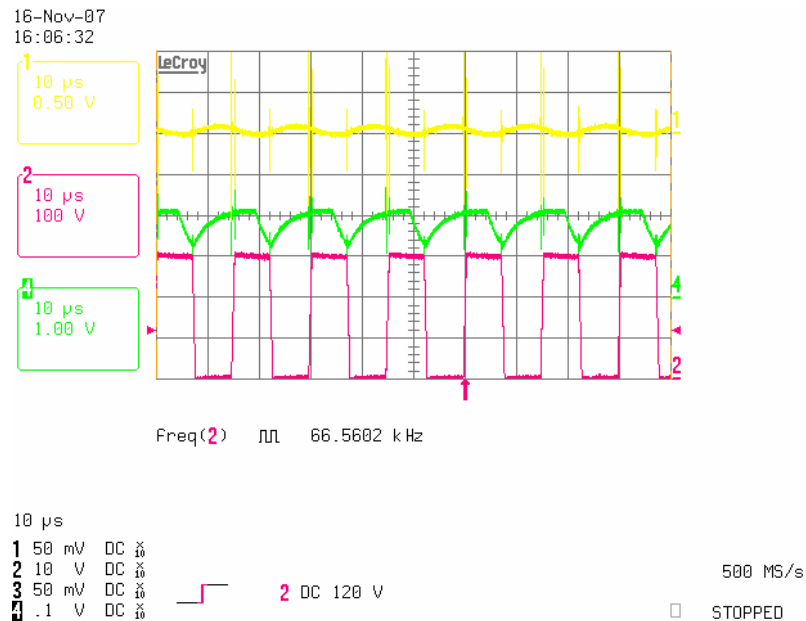


Figure 9.5: 10% dimming level waveforms: CH1 is the DIM voltage, CH2 is the voltage at VS pin, and CH4 is the VCO voltage

## 10. Fault Conditions

In case of fault conditions such as open filaments, failure to strike, or lamp removal, the IRS2530D will go into Fault Mode. In this mode, the internal fault latch is set, HO is off, LO is open circuit, and the IRS2530D consumes an ultra-low micro-power current. The IRS2530D can be reset with a lamp exchange (as detected by the LO pin) or a recycling of VCC below and back above the UVLO thresholds.

### Failure to Strike

At initial turn-on of the ballast, the frequency will ramp down from  $f_{MAX}$  toward the resonance frequency. When the lamp fails to strike, the VCO voltage continues to increase and the frequency continues to decrease until the VCO voltage exceeds VVCOFLT+ (4.0V, typical), and the IRS2530D enters Fault Mode and shuts down (Figure 10.1). It should be noted that in case of failure to strike, the system will operate in capacitive side of resonance, but only for short period of time.

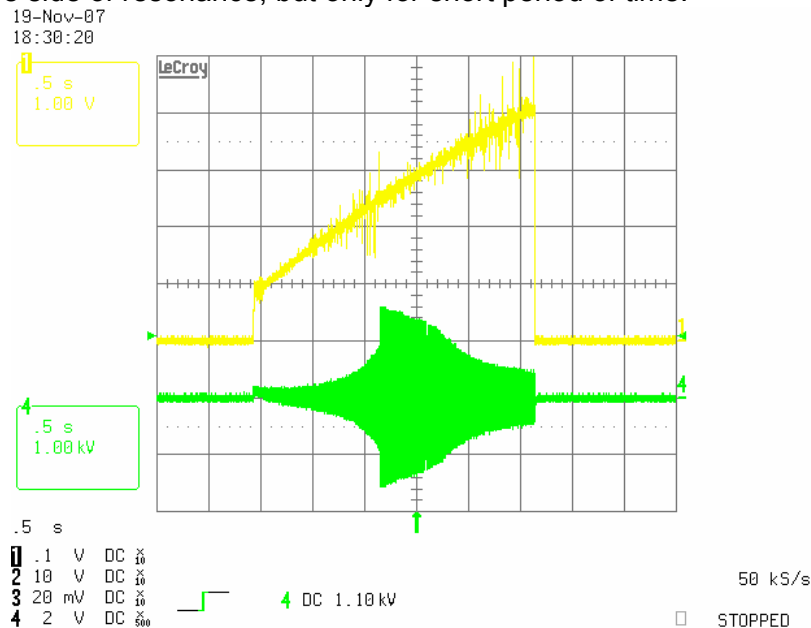


Figure 10.1: Lamp non-strike: CH1 is the VCO voltage, CH4 is the voltage across lamp

### AC Mains Interrupt / Brown-Out Conditions

This protection relies on the non-ZVS circuit of IRS2530D, enabled in the Dim Mode. During an AC mains interrupt or brown-out condition, the DC bus can decrease and cause the system to operate too close to, or, on the capacitive side of resonance. The result is non-ZVS switching that causes high peak currents to flow in the half-bridge MOSFETs that can damage or destroy them.

To protect against this, the IRS2530D will detect non-ZVS by measuring the VS voltage at each rising edge of LO. If the voltage is greater than VZVSTH (4.5V, typical), the IC will reduce the voltage at VCO pin, and thus increase the frequency until ZVS is reached again (Figure 10.2).

In case the DC bus decreases too far and the lamp extinguishes, the VCC voltage will go below VCCUV- (10.5V, typical) and the ignition/preheat ramp will be reset to re-ignite the lamp reliably.

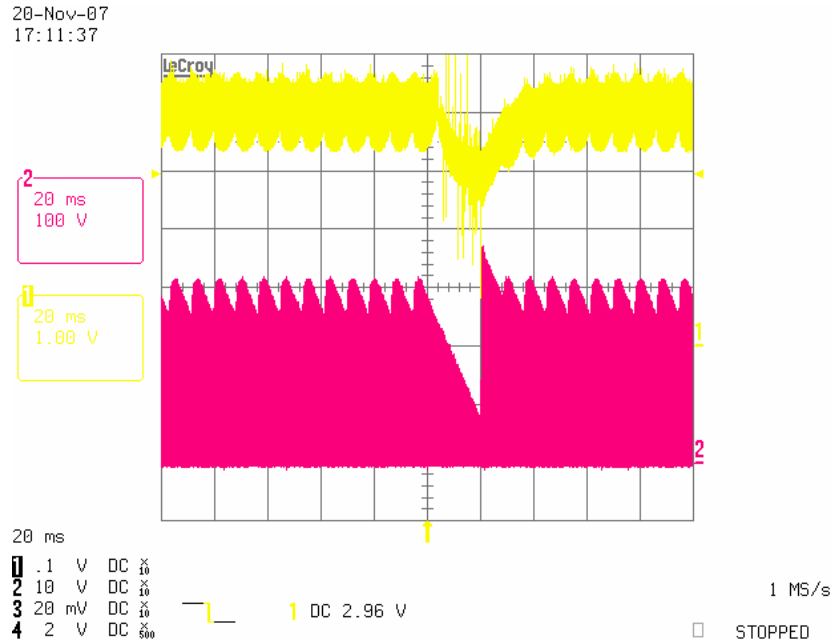


Figure 10.2: Brown-out conditions: CH1 is the VCO voltage, CH2 is the VS voltage

## Lamp Removal

When the lamp is removed, the IRS2530D uses the Crest Factor Over-current Protection to enter the Fault mode and shut down. During lamp removal, the output stage will transition to a series-LC configuration, and the frequency will move towards resonance until the inductor saturates. The IRS2530D uses the VS-sensing circuitry and the  $R_{DSon}$  of the low-side half-bridge MOSFET to measure the MOSFET current for detecting an over-current fault. Should the peak current exceed the average current by a factor of 5.5 ( $CF > 5.5$ ) during the on-time of LO, the IRS2530D will enter Fault Mode, where the half-bridge is off. Performing crest factor measurement provides a relative current measurement that cancels temperature and/or tolerance variations of the  $R_{DSon}$  of the low-side half-bridge MOSFET.

Figure 10.3 shows the voltage across the lamp and the VS voltage when the lower filament of the lamp is removed. Figure 10.4 shows these voltages when the upper filament of the lamp is removed. In both cases, the IRS2530D will enter the Fault Mode and shut down after detecting that the crest factor exceeds 5 during the on-time of LO. Figure 10.5 shows the VS pin, inductor current, and voltage across lamp when the inductor saturates and the ballast shuts down.

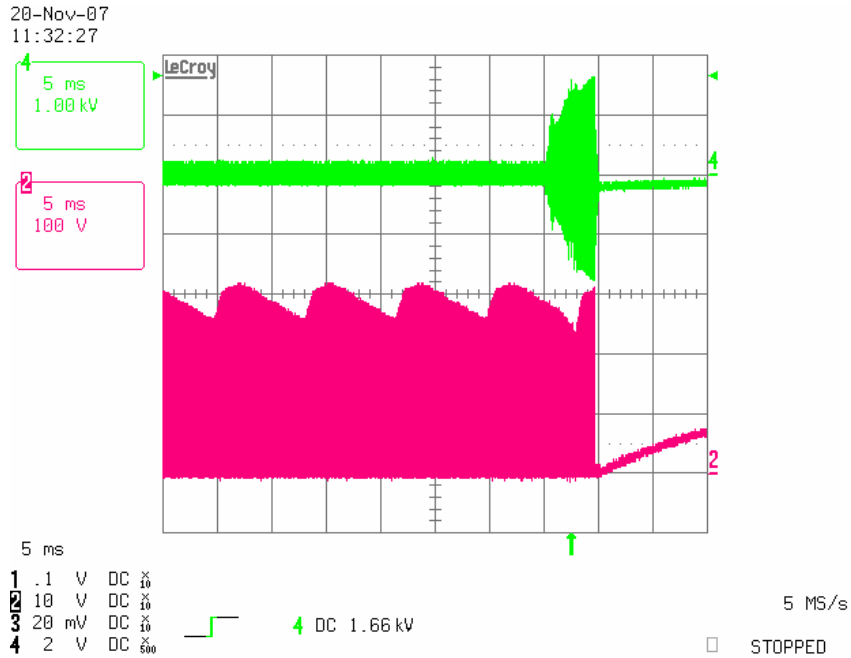


Figure 10.3: Lower filament removed: CH2 is the VS voltage, CH4 is the voltage across the lamp

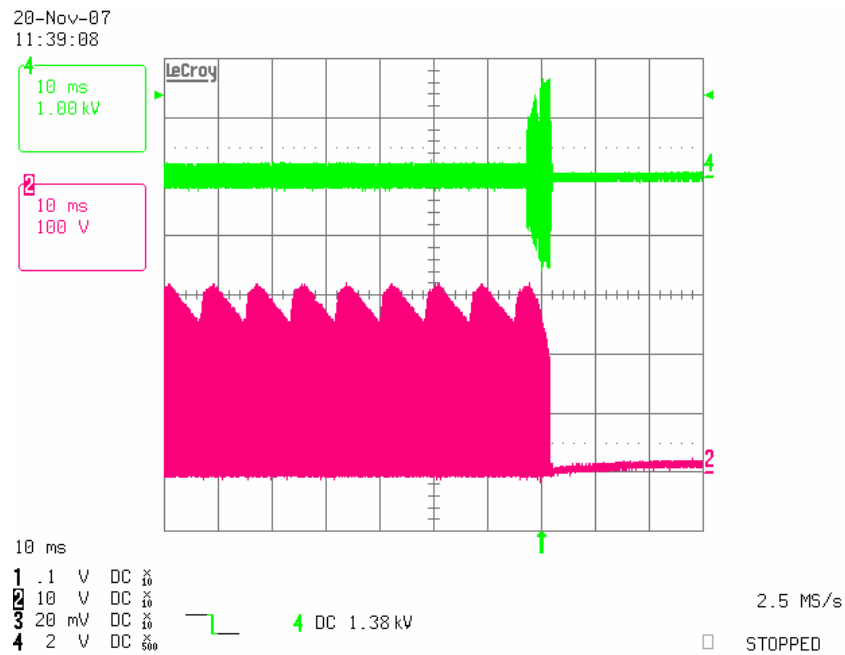


Figure 10.4: Upper filament removed: CH2 is the VS voltage, CH4 is the voltage across the lamp

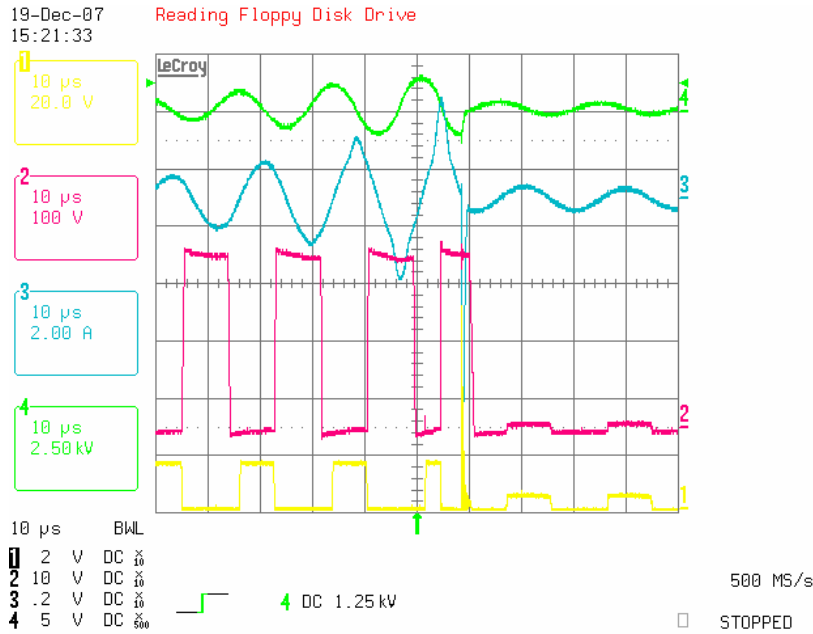


Figure 10.5: Inductor saturation: CH1 is the LO voltage, CH2 is the VS voltage, CH3 is the current through the resonant inductor, and CH4 is the voltage across the lamp

Figure 10.6 shows the VS voltage and the voltage across the lamp when the IC undergoes reset with a lamp exchange. When the lamp is removed, crest factor protection is triggered, and the IC enters the Fault mode and shuts down. Since the lamp is removed, LO pins is pulled above VLOSD+, and the IC goes to UVLO mode. When the lamp is re-inserted, the IC goes back to the Preheat / Ignition mode, and the half-bridge starts to oscillate again.

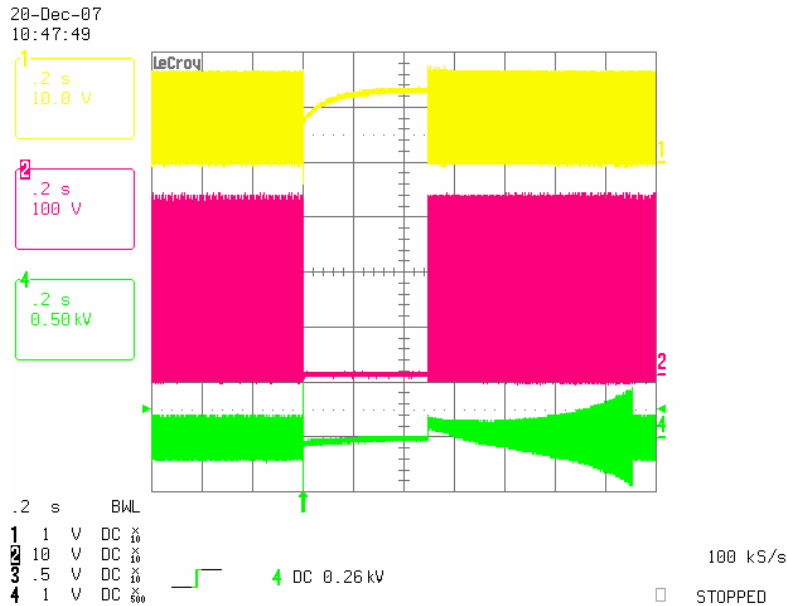
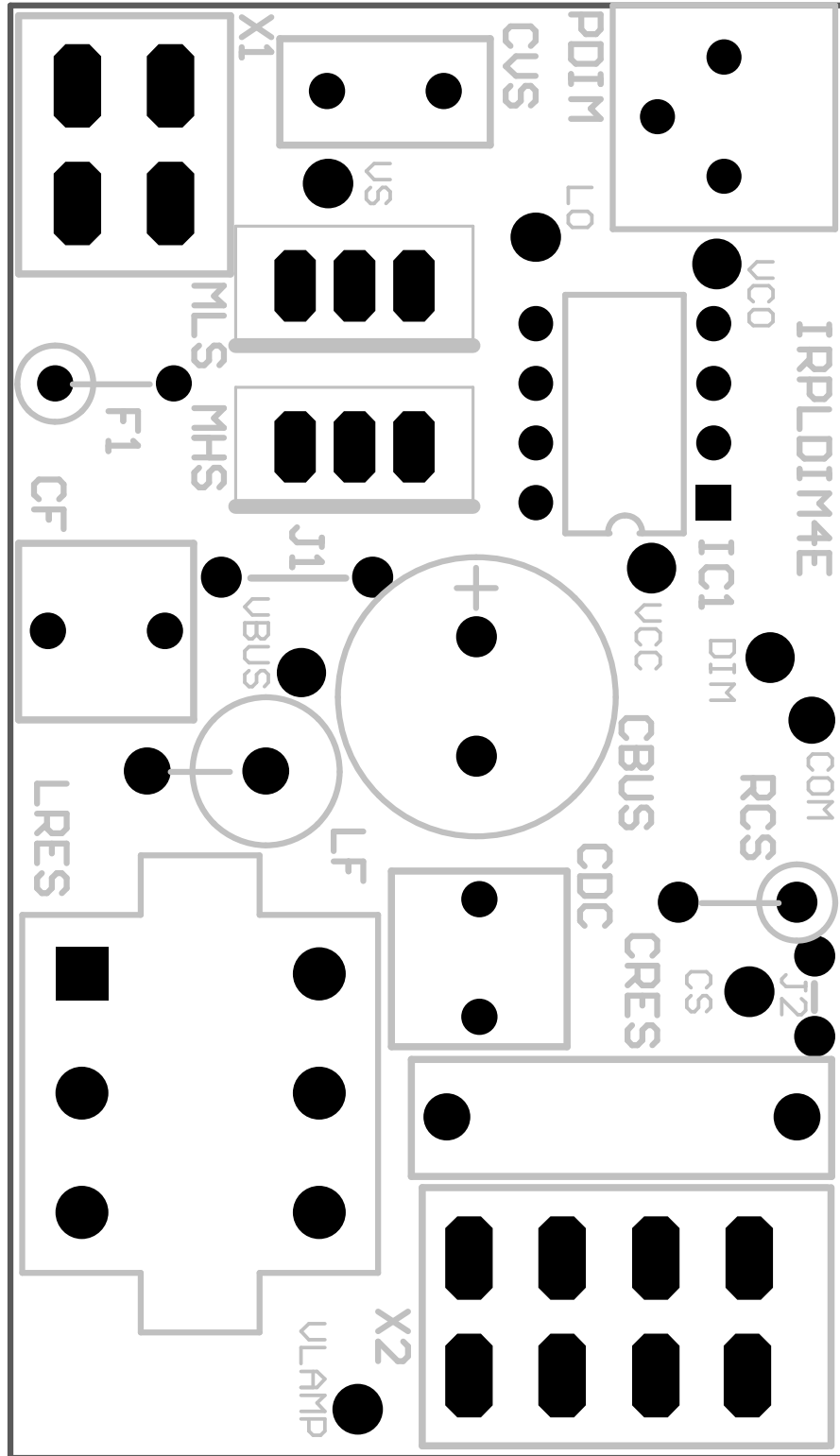
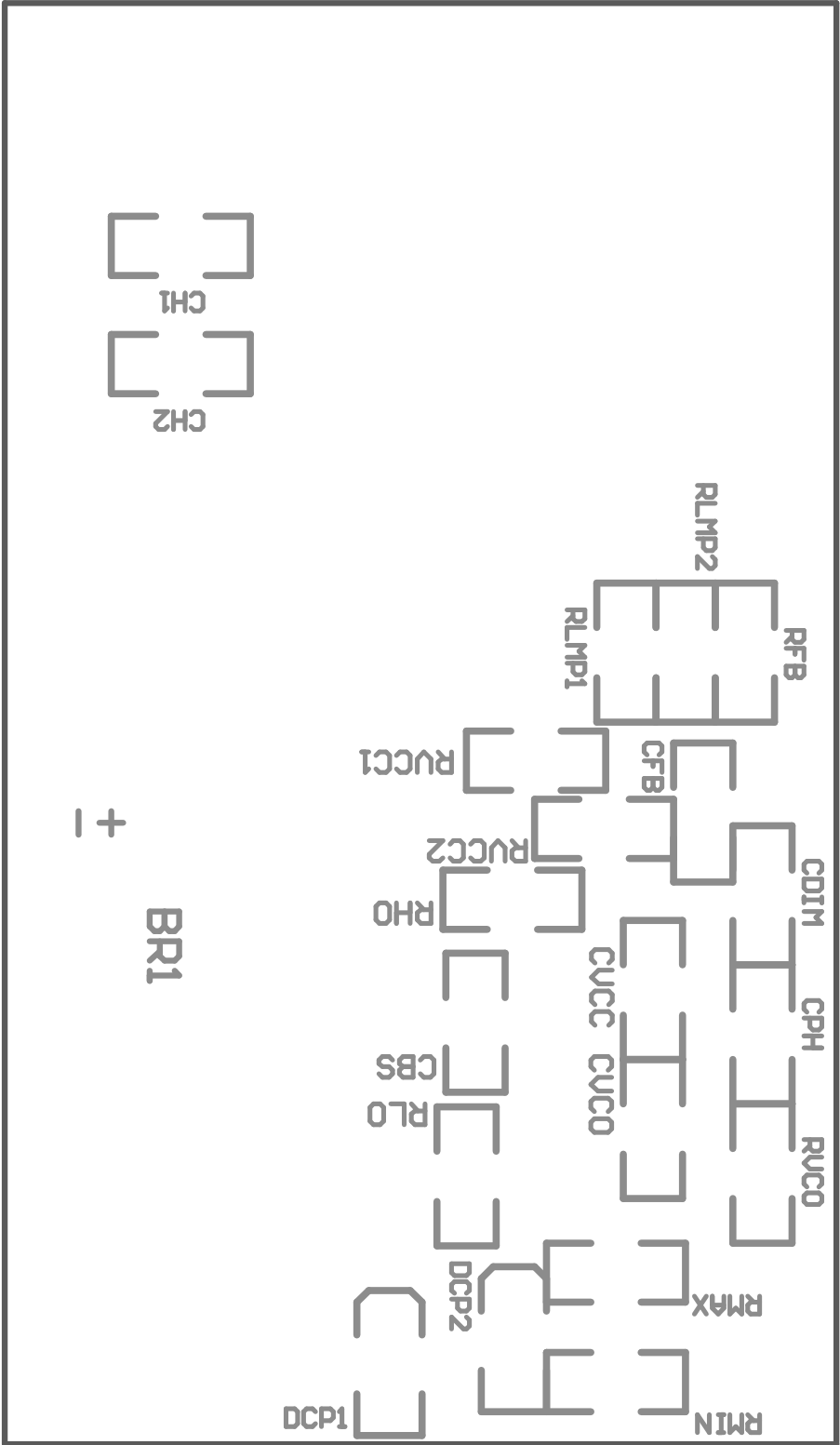


Figure 10.6: Lamp exchange: CH1 is the LO voltage, CH2 is the VS voltage, and CH4 is the voltage across the lamp

### 11. PCB Layout and Component Placement

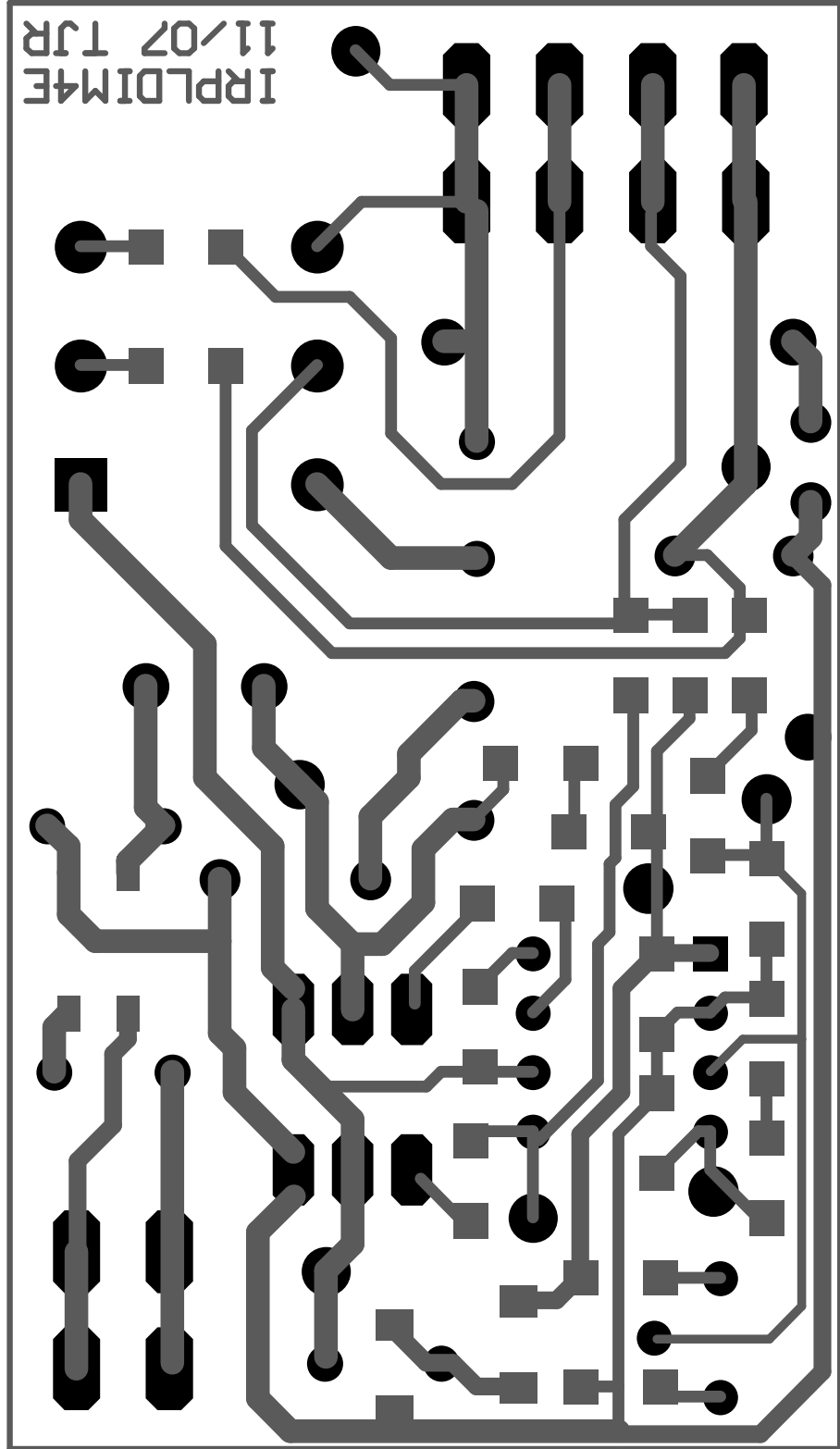
Top Silk Screen Layer





Bottom Silk Screen Layer

Bottom Copper Layer






## 12. Inductor Specifications

Vogt # IL 070 503 11 02

BI Technologies # HM00-07544



### INDUCTOR SPECIFICATION

CORE SIZE

GAP LENGTH  mm

CORE MATERIAL

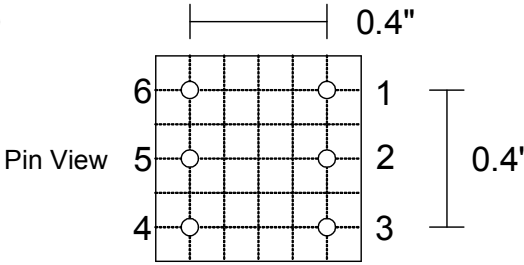
NOMINAL INDUCTANCE  mH

TEST TEMPERATURE  C

| WINDING | START PIN | FINISH PIN | TURNS | WIRE DIAMETER (mm)   |
|---------|-----------|------------|-------|----------------------|
| MAIN    | 1         | 6          | 240*  | 10/ 38 Multistranded |
| CATHODE | 2         | 5          | 5.5   | 26 awg insulated     |
| CATHODE | 3         | 4          | 5.5   | 26 awg insulated     |

PHYSICAL LAYOUT  
( Vertical6- Pin Bobbin)



TEST TEST TEMPERATURE  C

MAIN WINDING INDUCTANCE  mH

\* Adjust turns for specified Inductance mH

# Mouser Electronics

Authorized Distributor

Click to View Pricing, Inventory, Delivery & Lifecycle Information:

[Infineon:](#)

[IRPLDIM4E](#)



Компания «ЭлектроПласт» предлагает заключение долгосрочных отношений при поставках импортных электронных компонентов на взаимовыгодных условиях!

Наши преимущества:

- Оперативные поставки широкого спектра электронных компонентов отечественного и импортного производства напрямую от производителей и с крупнейших мировых складов;
- Поставка более 17-ти миллионов наименований электронных компонентов;
- Поставка сложных, дефицитных, либо снятых с производства позиций;
- Оперативные сроки поставки под заказ (от 5 рабочих дней);
- Экспресс доставка в любую точку России;
- Техническая поддержка проекта, помощь в подборе аналогов, поставка прототипов;
- Система менеджмента качества сертифицирована по Международному стандарту ISO 9001;
- Лицензия ФСБ на осуществление работ с использованием сведений, составляющих государственную тайну;
- Поставка специализированных компонентов (Xilinx, Altera, Analog Devices, Intersil, Interpoint, Microsemi, Aeroflex, Peregrine, Syfer, Eurofarad, Texas Instrument, Miteq, Cobham, E2V, MA-COM, Hittite, Mini-Circuits, General Dynamics и др.);

Помимо этого, одним из направлений компании «ЭлектроПласт» является направление «Источники питания». Мы предлагаем Вам помощь Конструкторского отдела:

- Подбор оптимального решения, техническое обоснование при выборе компонента;
- Подбор аналогов;
- Консультации по применению компонента;
- Поставка образцов и прототипов;
- Техническая поддержка проекта;
- Защита от снятия компонента с производства.



#### Как с нами связаться

**Телефон:** 8 (812) 309 58 32 (многоканальный)

**Факс:** 8 (812) 320-02-42

**Электронная почта:** [org@eplast1.ru](mailto:org@eplast1.ru)

**Адрес:** 198099, г. Санкт-Петербург, ул. Калинина, дом 2, корпус 4, литера А.