Reference Design

Fluorescent Ballast with ZAURA Control

RD001102-0814

Overview

This reference design integrates Zilog's ZAURA RF 868MHz Wireless Module onto a Fluorescent Ballast Base Power Board to create a Fluorescent Ballast Demonstration Board designed to showcase the features and performance of an inductor-based fluorescent lamp driver with active power factor correction (PFC) and a microcontroller (MCU). This reference design can be used as a basis for developing systems that can control fluorescent lighting installations.

On its own, without the ZAURA RF Wireless Module attached, the Base Power Board functions as a demonstration board, providing current to power fluorescent lamps. However, the Fluorescent Ballast Base Power Board cannot control lamp brightness because the source of the PWM pulses required to perform this operation is generated by the Z8F2480 MCU on the RF Module.

In combination, the Fluorescent Ballast Base Power Board with the Module attached, all controlled by a hand-held remote control device, enable RF communication to turn fluorescent lamps on and off, and to adjust the brightness of these fluorescent lamps within a 10%–100% range.

For purposes of demonstrating RF control, the hand-held ZAURA RF Remote Control device is also included with this reference design[1]. See the Remote Control Operation section on page 9 for a description of this remote control device.

Note: If you wish to develop RF remote control software, Zilog recommends purchasing the ZAURA RF Wireless 868MHz Module Development Kit, because the hand-held ZAURA RF Remote Control device included with this reference design uses the same hardware and software libraries as this development kit.

Features

This Fluorescent Ballast with ZAURA Control reference design includes the following features:

- Fluorescent Ballast Base Power Board
  - 80W output power
  - Two-lamp testing capability

1. This reference design does not include fluorescent lamps.

- ZAURA RF 868 MHz Wireless Module
- Remote brightness and on/off control
- 180 VAC to 230 VAC input

Required Items Not Supplied

To run this Fluorescent Ballast with ZAURA Control demonstration, the following items will be required in addition to the contents of this reference design:

- One 3-wire AC cord/cable
- Fixture with two 39 W 40" fluorescent lamps (TL5HO39W)
- 3 mm flathead screwdriver

Potential Applications

This reference design can be used to develop a number of applications; the brief list below offers a few ideas.

- Remote-operated commercial or architectural lighting
- Private lighting with remote control convenience features
- Central control of dimmable lighting without wiring or infrastructure changes

Discussion

The Fluorescent Ballast Demonstration Board is simply comprised of the Fluorescent Ballast Base Power Board with Zilog's ZAURA RF Wireless Module affixed to it, as shown in Figure 1 (the Module is located on the right side of the figure). The Base Power Board is a two-layer surface-mount board that provides easy probe access points to all fluorescent ballast inputs and outputs, allowing the user to quickly connect and measure electrical characteristics and waveforms. The ZAURA RF Wireless Module is a four-layer board featuring an MCU, an RF transceiver, an antenna and passive components.

Figure 1. Fluorescent Ballast with ZAURA Control Demonstration Board

The Base Power Board and attached ZAURA Module are powered from a single-phase AC line with a 180–230 V voltage range. The Base Power Board provides approximately 80 W of output power to drive two 39 W 40" fluorescent lamps (TL5HO39W) connected in parallel.

The dimensions of the Fluorescent Ballast Base Power Board are 10.5" (L) x 1.4" (W) x 1.2" (H). A block diagram of the Board is shown in Figure 2.

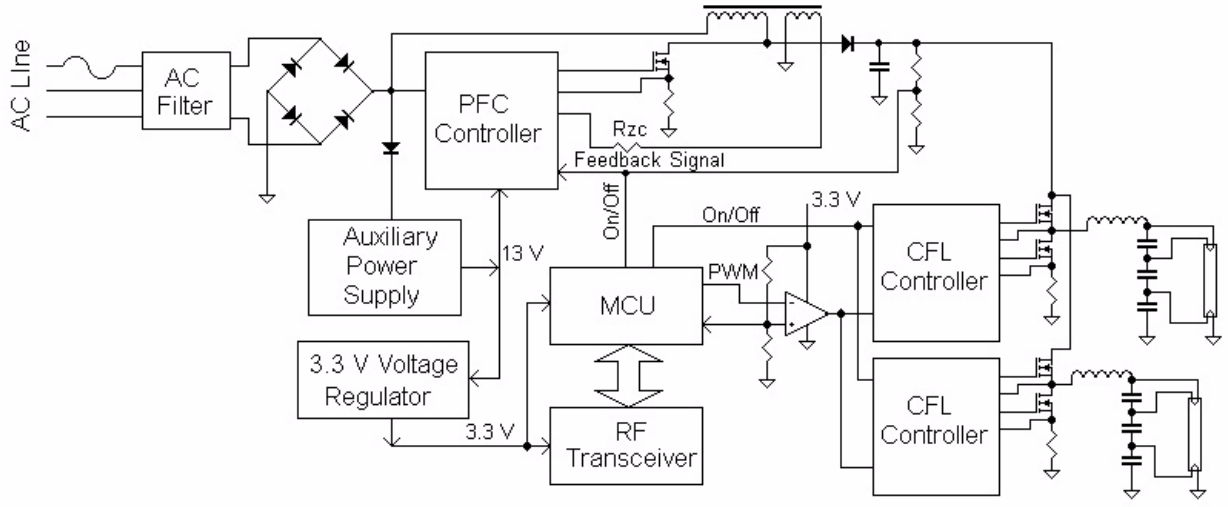

Figure 2. Fluorescent Ballast with ZAURA Control Demonstration Board Block Diagram

Warning: The Base Power Board and the ZAURA RF Module are electrically connected to AC power. The Base Power Board contains points with high voltage (up to 800 V). If any measurements will be performed on the Board, a power supply with isolation transformers should be used to avoid electrical shock. Persons working with this Board should be fully qualified to work with high-voltage devices.

Fluorescent Ballast Base Power Board

The Fluorescent Ballast Base Power Board, shown in Figures 3 and 4, contains PFC Controller U1 (L6562A, FAN7527B, or any other direct replacement) with switch Q1 (IXTP7N60P) and transformer T1. For reference, see Appendix A. Schematic Diagrams on page 20.

Figure 3. Fluorescent Ballast Base Power Board, Top View

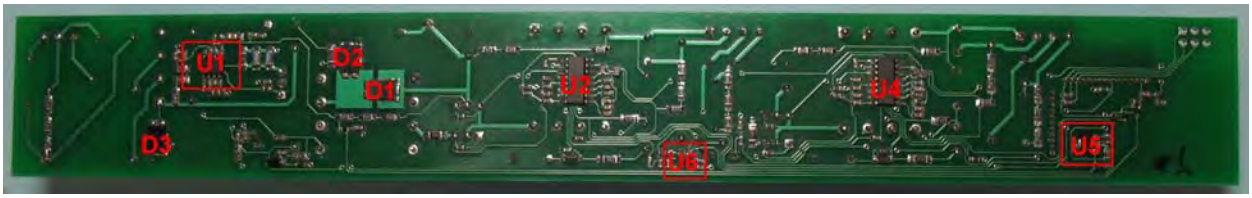

Figure 4. Fluorescent Ballast Base Power Board, Bottom View

An auxiliary power supply with a depletion mode MOSFET Q2 (IXTA08N50D2) provides approximately 13V to start the PFC from Standby Mode and to power the MCU when in Standby Mode.

Voltage regulator U9 (XC6216B33ER) provides 3.3V to power the MCU. Voltage doublers D4, ZD5, C14, R9 provide power to the PFC and the MCU during normal PFC operation.

Note: For more information about the operation and selection of the PFC Controller's surrounding components, see the L6562A Transition Mode PFC Controller Specification from ST Micro.

Power filter U3 (FPP-01) decreases electrical noise generated by board into AC net. The 400V DC voltage from the PFC, when applied to fluorescent lamp controllers U2, U4 (UBA2014T from NXP), provide all necessary functions required to operate two fluorescent lamps. The lamp drivers operate in series-resonant mode with MOSFETs Q4, Q5 and Q7, Q8, respectively (IXFP3N50PM IXYS), pumping energy into the resonant circuitry created by inductors L1, L2 and capacitors C27, C46.

Resistors R28, R41, R42, R44–R46 and the identical network R52, R54–R56, R67, R68 provide initial start-up voltage for U2 and U4, respectively. If a fluorescent lamp is not connected, or if filament F1 is broken, the drivers will not start.

Capacitive divider C20/C21 with diodes D8, D5, and identical circuitry C37/C43 with diodes D6, D9 provide power for U2 and U4 during normal operation.

Network C28, C29, D7, R31, R32, C30 creates a signal which U2 monitors to determine fluorescent lamp conditions during preheat, ignition, and normal operation. If this voltage is below or above a level determined for the current lamp state, operation is aborted and U2 goes into Standby Mode. The identical network C44, C39, D10, R61, R65, C40 creates a signal for U4.

Power should be cycled to restart operations.

Op amp U6 converts PWM pulses from the MCU into reference voltage for fluorescent lamp drivers U2, U4 to regulate fluorescent lamp brightness.

Reference voltage from resistive divider R53/R26 is applied to the noninverting U2, U4 error amplifier's input, while the actual fluorescent lamp current is applied to inverting input from current sense resistors R5 and R69, respectively. An error signal changes the voltage at the U2, U4 voltage-controlled oscillator, changing switching frequency to adjust fluorescent lamp current.

Note: For more information about the operation and selection of the fluorescent lamp controller's surrounding components, see the UBA2014T 600 V Driver IC for HF Fluorescent Lamps Specification from NXP.

Resistor R29 adjusts fluorescent lamp brightness.

Note: Zilog does not recommend decreasing fluorescent lamp brightness below 10% of the maximum value, because the lamp may become unstable or shut off completely due to very low current.

Signals from the U2, U4 V_{REF} outputs are used by the MCU to monitor U2 and U4 activity. If, for any reason, both drivers go into Standby Mode, the MCU will also turn off the PFC Controller to decrease current consumption.

ZAURA RF Wireless Module

The ZAURA RF Wireless 868MHz Module, shown in Figure 5, features a Z8F2480 MCU[2] U14 (in a 44-pin QFN package), an RF transceiver U2 (SX1211), an antenna, and passive components required by the transceiver for proper operation. For more information about the functions and characteristics of these components, refer to the ZAURA RF Wireless Modules Product User Guide (PUG0030); also see the Getting Started with ZAURA RF Control Application Note (AN0336).

2. The Z8F2480 MCU is a member of Zilog's Z8 Encore! XP family of 8-bit microcontrollers.

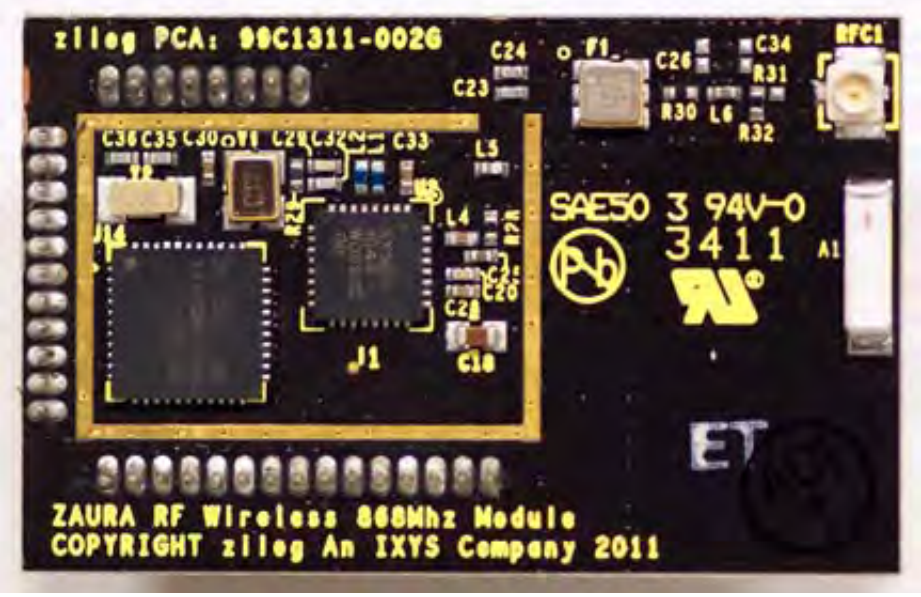

Figure 5. ZAURA RF Wireless Module

Principles of Operation

After power-up, auxiliary power supply provides ~13 V to start PFC controller and MCU. As soon as PFC controller becomes active, board provides a maximum preset output current, and the MCU awaits commands from the ZAURA RF Remote Control device.

When the PFC Controller is active, the auxiliary power supply is disabled, and power to the PFC Controller and to the MCU is delivered from the transformer's secondary winding.

The commands transmitted from the RF remote unit allow the PFC Controller to be turned on and off, and to set fluorescent lamp current.

To turn the PFC Controller off, the MCU sets the gates of MOSFETs Q3, Q6 and Q9 to logic Low. As a result, 3.3 V from voltage regulator U9 is applied to a PFC feedback network, setting the PFC into an overvoltage protection mode and disabling it. The same voltage, when applied to the LVS pin of each lamp controller, turns the lamp controllers off as well, setting both into Standby Mode. During this state, the auxiliary power supply provides power to the PFC and the MCU. If a command to turn the PFC on from the ZAURA RF Remote Control device is recognized, the MCU sets the Q3, Q6 and Q9 gates to logic High, and the PFC returns to normal operation mode, with the fluorescent lamp current equal to the value set prior to the PFC being turned off.

MOSFETs Q10 and Q11 create a reset signal for U2 and U4 at the rising edge of the ON signal to allow them to start in normal operation mode.

To adjust lamp current, the MCU generates PWM pulses (with a duty cycle in the range 0%–100%) in 16 steps according to commands from the ZAURA RF Remote Control device. These steps allow the user to sequentially decrease or increase lamp brightness.

PWM pulses with duty cycles greater than zero increase the PFC feedback signal and proportionally decrease the lamp current required to hold the feedback signal at the same level. Resistor R29 changes the proportion between the lamp current and PWM signals, which changes the lamp current at the same PWM duty cycle.

Setup, Configuration and Use

This section describes how to set up, configure and operate the Fluorescent Ballast with ZAURA Control reference design.

Warning: The Base Power Board and the ZAURA RF Module are electrically connected to AC power. The Base Power Board contains points with high voltage (up to 800 V). If any measurements will be performed on the Board, a power supply with isolation transformers should be used to avoid electrical shock. Persons working with this Board should be fully qualified to work with high-voltage devices.

Powering the Fluorescent Ballast Demonstration Board

The Base Power Board should be powered from a single-phase AC source with a voltage range of 180 V–230 V RMS. If any measurements are to be performed, an insulated power source should be used to avoid the hazards of electrical shock and board damage.

The AC line should be connected as follows; see Figure 6 for reference:

- AC phase (black wire) to J5-1 (the left-most terminal)
- AC neutral (white wire) to J5-2 (the center terminal)
- AC ground (green wire) to J5-3 (the right-most terminal)

Each lamp should be connected to the Base Power Board before powering up the Board, as follows:

- Lamp 1, Filament 1 to slots 1 and 2 of Connector J6
- Lamp 1, Filament 2 to slots 3 and 4 of Connector J6
- Lamp 2, Filament 1 to slots 1 and 2 of Connector J7
- Lamp 2, Filament 2 to slots 3 and 4 of Connector J7

Note: Ensure that the two filaments on each lamp are connected to the same connector.

Figure 6 shows the connections to the 3-wire AC cord/cable and the Board.

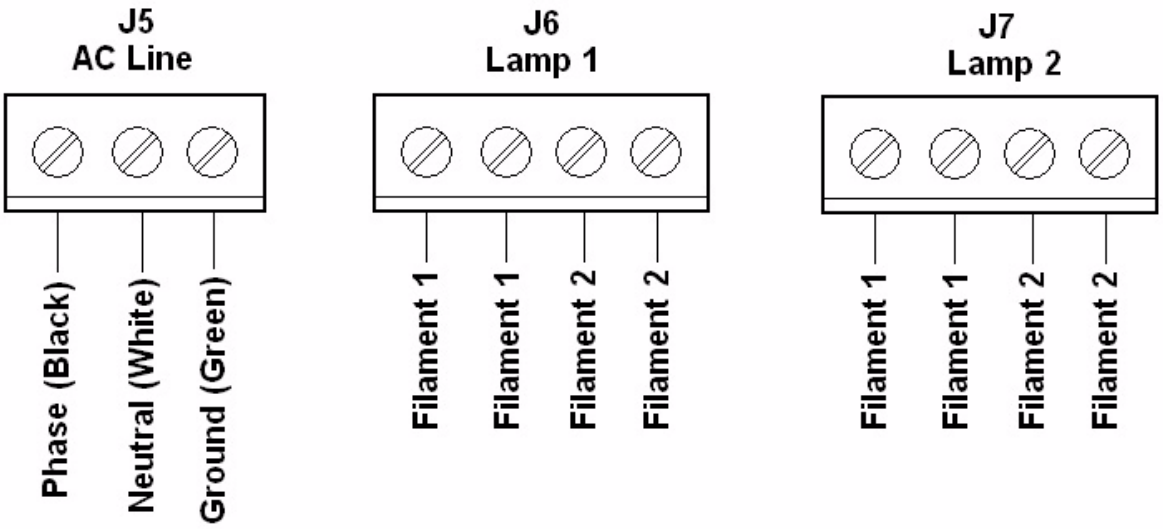

Figure 6. Connections to the Base Power Board

The Board wakes up and provides the maximum output current with a delay time of approximately 1.5 seconds to allow the fluorescent lamp to preheat.

Remote Control Operation

The ZAURA RF Remote Control unit, shown in Figure 7, is the hand-held RF remote control device that conveniently controls the ZAURA RF Module.

Figure 7. Hand-Held ZAURA RF Remote Control Device

Note: The remote unit's RSVD button currently does not function; it is designated for future use.

Observe the following procedure to understand and use the remote unit.

1. Install two AA 1.5V batteries (included in the kit) inside the remote control device.
2. With the Fluorescent Ballast Demonstration Board connected to an AC line, the lamp initially illuminates at maximum brightness. At this initialization phase, brightness can only be decreased (adjusted downward).

3. The remote unit offers 16 brightness levels. Experiment with the **DIM** button to decrease the level of brightness, and with the **BRIGHT** button to increase the level of brightness.
4. Use the **ON/OFF** button to turn the fluorescent lamps off. If the Fluorescent Ballast Base Power Board is still connected to an AC line, the Board remembers the last brightness level that was set, and will automatically return to this level after a three-second delay. This delay period allows the lamps heat up and stabilize the current each time the Board is turned on using the remote.

Setting the Fluorescent Lamp Current

The maximum fluorescent lamp current is determined by resonant circuitry parameters (L1C27 and L2C46) with respect to the type of lamp recommended (TL5HO39W). To use another type of lamp requires corrections to these resonant circuitry parameters for the fluorescent lamp driver UBA2014 used, as discussed in NXP Application Note AN10872.

The minimum fluorescent lamp current value can be adjusted by resistor R29, which changes the lamp driver's sensitivity to PWM pulses provided by the ZAURA RF Module.

Note: Zilog does not recommend setting the minimum lamp current below 10% of the maximum value, because the lamp's current may become unstable or the lamp may shut off completely, especially at low ambient temperatures.

Fluorescent Ballast Software Operation

When the MCU comes out of reset, it calls the `ZAURA_RF_Init()` API from the ZAURA RF Wireless Library to initialize the RF Controller. The `ZAURA_RF_Conf.c` file contains variables referenced by the ZAURA RF Wireless Library to establish a radio configuration compatible with the ZAURA RF remote control unit (i.e., a 50kbps data rate, a binary FSK signal centered at 866.2MHz with a 100KHz frequency deviation and a modulation index of 4). This configuration ensures that commands sent by the remote can be received by the fluorescent ballast.

After the radio has been configured, the fluorescent ballast is activated (the PFC is turned on) and is set to its maximum brightness (the PWM duty cycle is set to 0%).

The PWM signal generated by the MCU has a frequency of approximately 1.024KHz, with up to 33 PWM duty cycle settings that can range from 0% to 100% in increments of approximately 3%. Commands from the ZAURA RF remote control unit instruct the fluorescent ballast to use PWM settings from 0% to 100% in increments of approximately 6%. The software next enters an infinite loop in which the radio and MCU are placed into a low-power state to conserve energy and to periodically wake up to listen for RF commands from the ZAURA RF remote.

Approximately every 220ms, the MCU returns to Active Mode and calls the `ZAURA_RF_Set_State` API to enable reception of RF packets. When the radio is in

Receive Mode, the firmware waits approximately 22ms for a command from the ZAURA RF remote unit. If a command is not received, the radio and MCU return to Low Power Mode until the next 220ms wake-up interval. If an RF command is received, the `PktHandler()` routine retrieves the packet from the ZAURA RF Wireless Library and calls the `LedCtrlUpdate()` routine to adjust the PWM level and PFC signal, as appropriate.

Every time one of the unreserved buttons on the ZAURA RF remote is pressed, it transmits 11 small RF packets (each less than 2ms in duration) every 20ms, matching the receive periodicity of the fluorescent ballast software.

Viewing and Rebuilding the RF Module Software

The source code file provided with this Fluorescent Ballast with ZAURA Control reference design allows users to become familiar with the ZAURA RF Remote Control Unit without the expectation of modifying any parameters.

Note: If you wish to develop RF remote control software, Zilog recommends purchasing the ZAURA RF Wireless 868MHz Module Development Kit, because the hand-held RF remote unit included with this reference design uses the same hardware and software libraries as this development kit.

1. This Fluorescent Ballast project requires that you use the ZDSII – Z8 Encore! Integrated Development Environment. Download the latest version from the **Downloadable Software** category in the Zilog Store.
2. Run the software installation file and follow the on-screen instructions to install ZDSII.
3. Launch the ZDSII – Z8 Encore! application by navigating via the following default path:

   Start → Programs → Zilog ZDS II_Z8Encore!_<version_number> → ZDSII_Z8Encore!<version_number>
4. From the **File** menu, select **Open Project**. The Open dialog box appears.
5. Browse to the `RD0011_Fluorescent_Ballast` folder which, by default, is located in the following path:

   ```
   C:\Program Files\Zilog\ZAURA_RF_Wireless_<version_number>\
   RD0011_Fluorescent_Ballast
   ```
6. Select the `Fluorescent_Ballast.zdsproj` file from the `RD0011_Fluorescent_Ballast` folder, and click **Open** to display the initial ZDSII program screen. To view the source files, double-click the **Project Files** folder on the left side of the IDE interface. Double-click an individual file to open the file in the ZDSII file editor.

7. Select the `866p5_MHz` build configuration file from the ZDS II toolbar. This menu is highlighted in red in Figure 8.

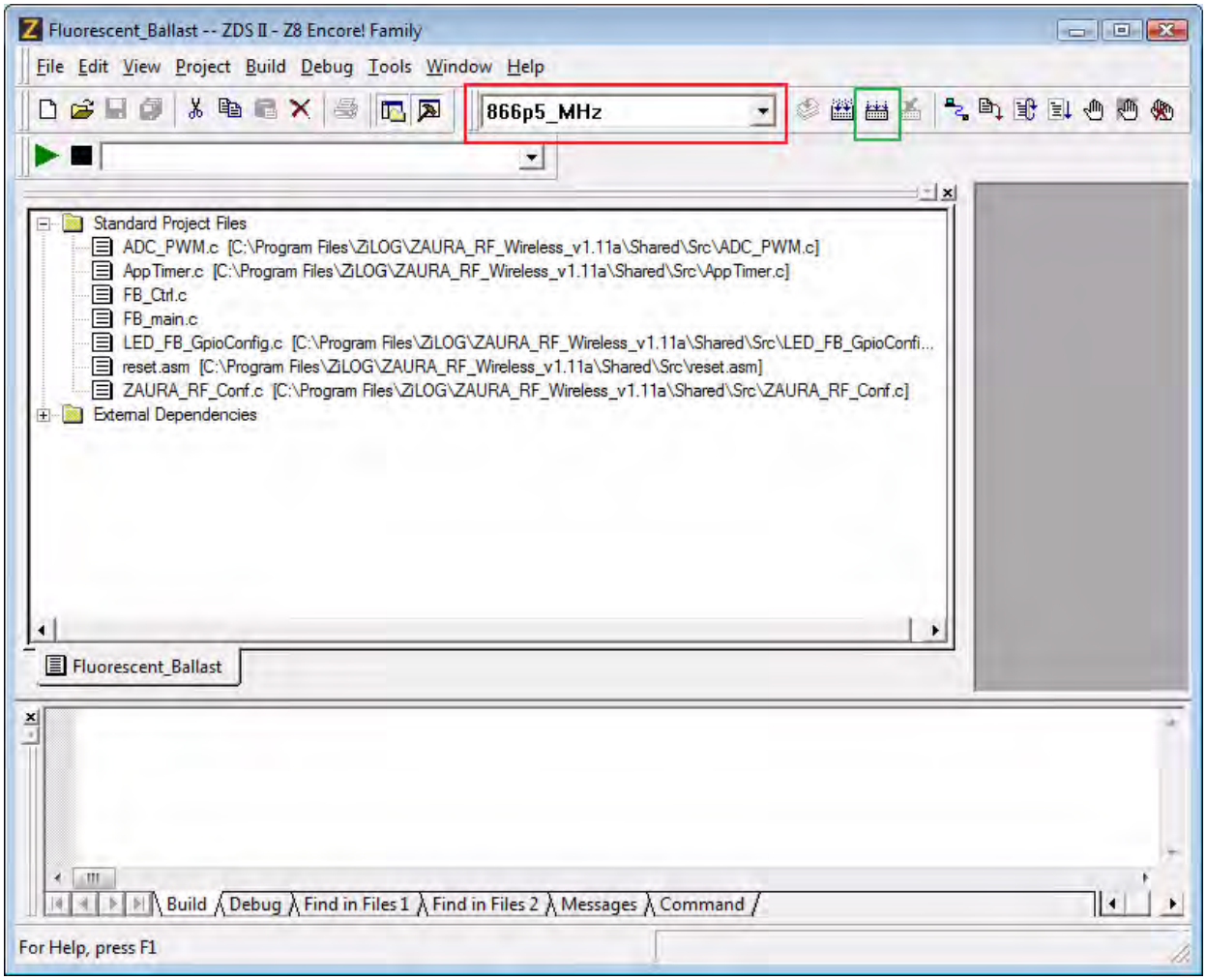

Figure 8. Build Mode Configuration

8. Click the **Rebuild All** toolbar icon, which is highlighted in green in Figure 8.
9. When the rebuild is complete, a `Build succeeded.` message will appear, as highlighted in Figure 9.

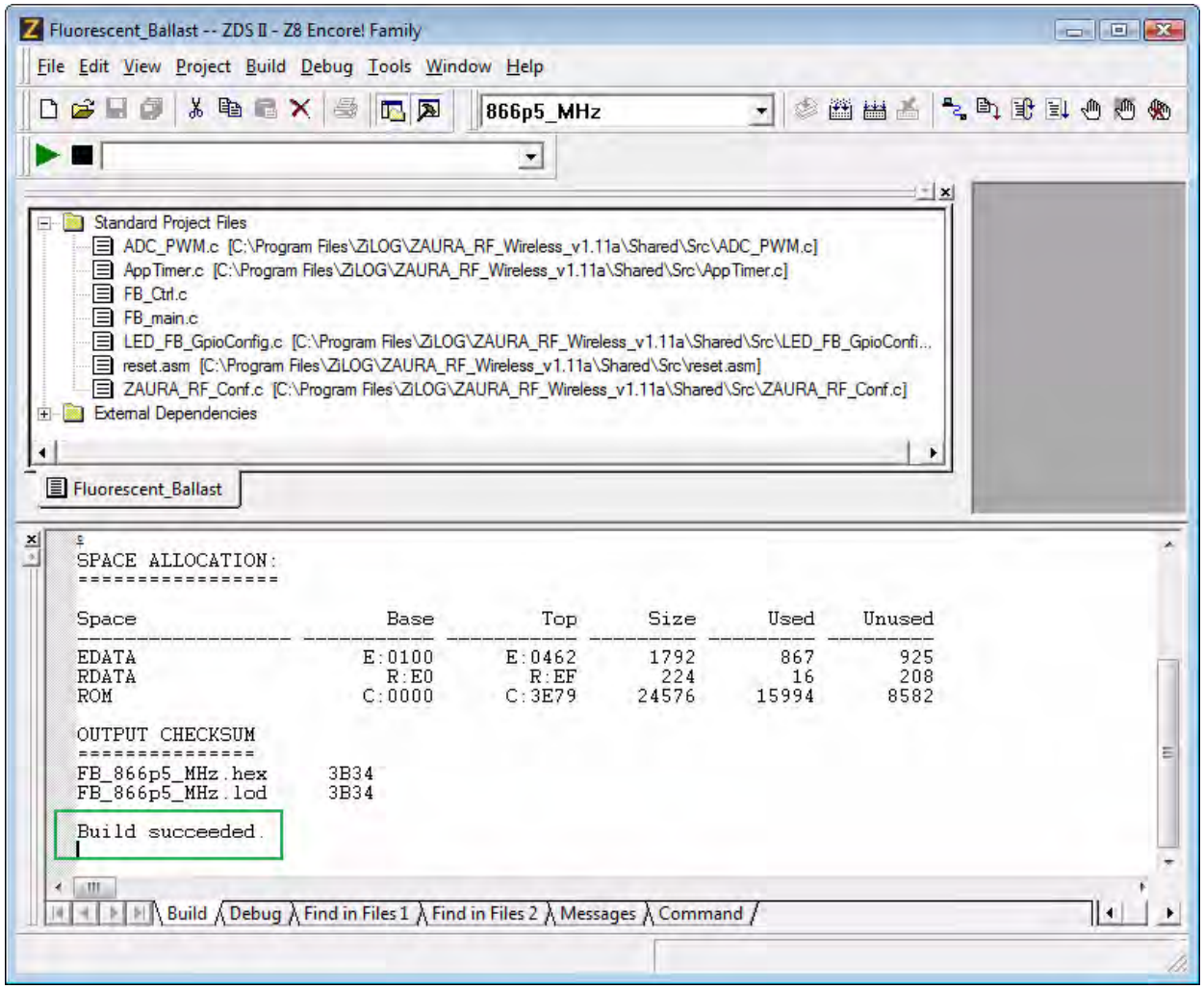

Figure 9. A Successful Build

Electrical Specifications

This section describes the electrical characteristics of the Fluorescent Ballast Demonstration Board. The data that follows describes the electrical characteristics of the Fluorescent Ballast Demonstration Board under load conditions and reflects all available data as a result of testing prior to qualification and characterization. As such, the data presented in this document is subject to change.

Absolute Maximum Ratings

Stresses greater than those listed in Table 1 may cause permanent damage to the Base Power Board. These ratings are stress ratings only; operation of the device at any condi-

tion outside those indicated in the operational sections of these specifications is not implied. Exposure to absolute maximum rating conditions for extended periods can affect device reliability.

Table 1. Absolute Maximum Ratings

Parameter	Rating	Unit
AC voltage RMS maximum	250	V
Output power	80	W
Storage temperature range	–65 to +160	°C
Operating temperature range	–40 to +65	°C

Recommended Operating Conditions

Table 2 lists the recommended voltage and temperature ranges for optimal operation of the Base Power Board.

Table 2. Recommended Operating Conditions

Parameter	Rating	Unit
AC voltage RMS range	180–230	V
Ambient temperature range	–20 to +45	°C

When the Base Power Board is operating under recommended conditions, the parameters listed in Table 3 are guaranteed, unless specified otherwise.

Table 3. Electrical Parameters

Name	Conditions	Min	Typ	Max	Units
Base Power Board output power	Two TL5HO39W lamps illuminated		78	80	W
Fluorescent lamp brightness control range		10		100	%
RF remote control device operating frequency			866.2		MHz
RF remote control device operating distance			30		m

Waveforms

Figures 10 and 11 show waveforms for the operation of the Base Power Board when fluorescent lamp current is at preheat, at ignition, and at normal operational conditions when at full current.

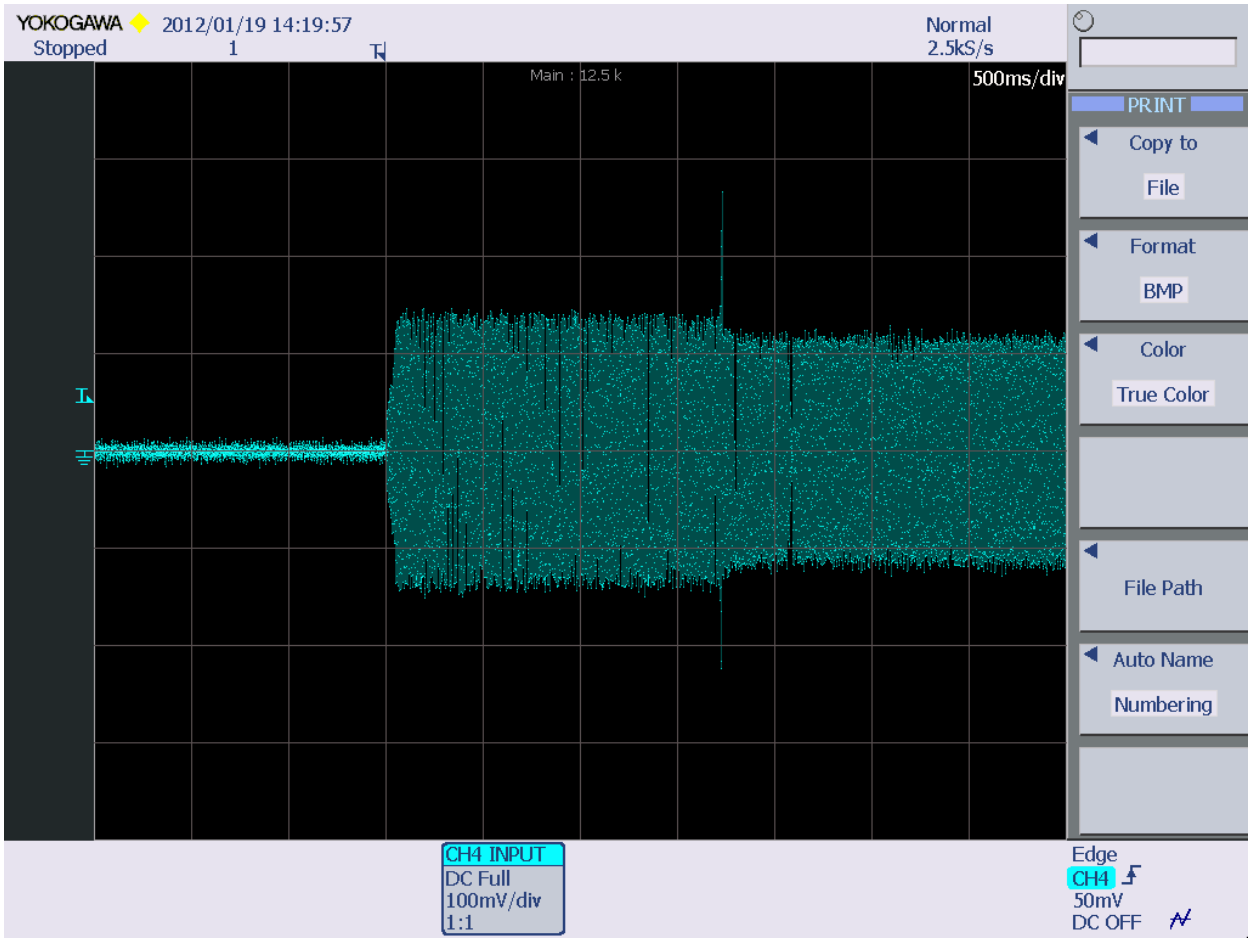

Figure 10. Fluorescent Lamp Current at Preheat, Ignition and Normal Conditions

Figure 11 demonstrates the fluorescent lamp voltage during normal operation at full current. Lamp voltage (Channel 2) is indicated in green, and lamp current (Channel 4) is indicated in blue.

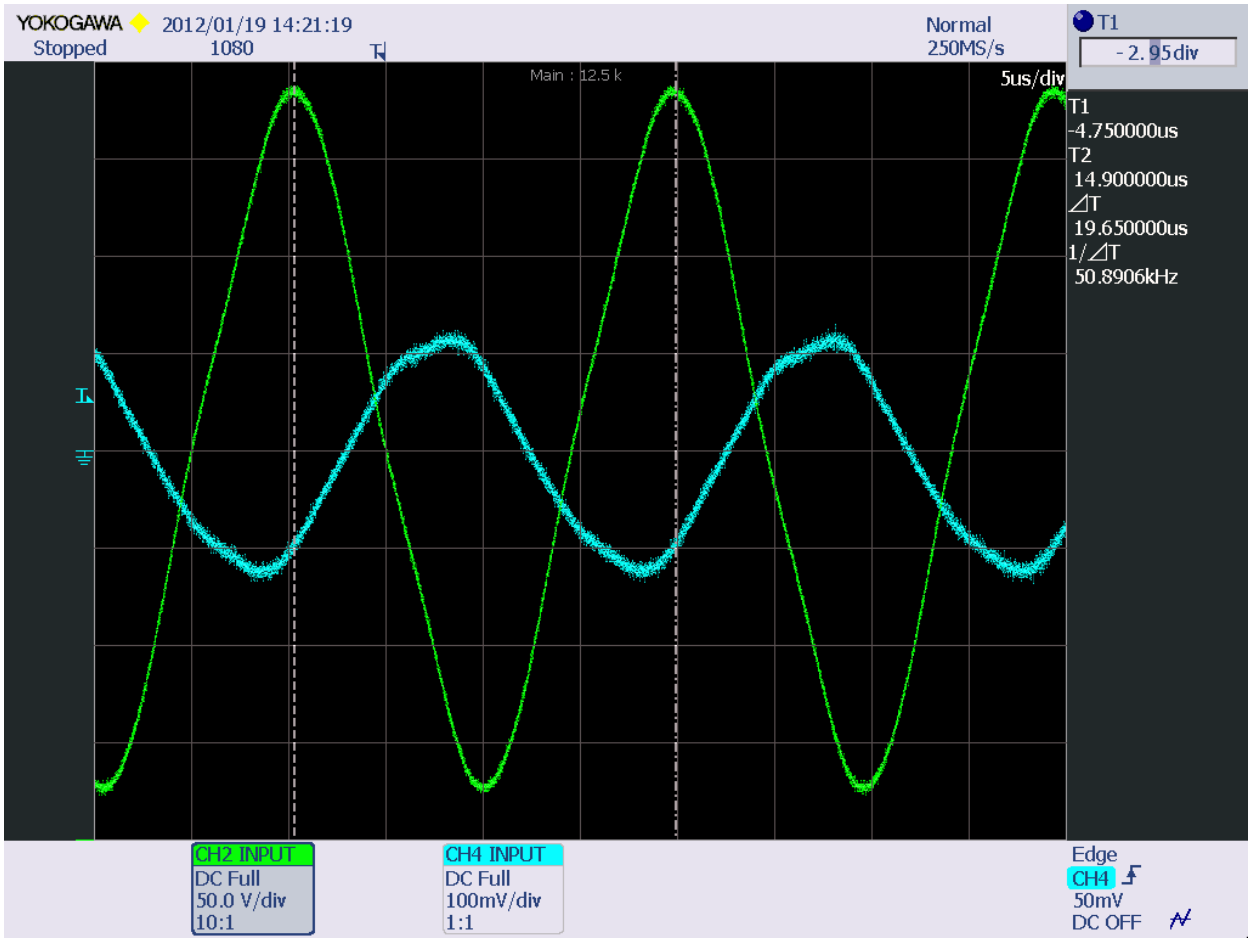

Figure 11. Fluorescent Lamp Voltage and Current at Full Current

Figure 12 demonstrates the fluorescent lamp voltage during normal operation at minimum current. Lamp voltage (Channel 2) is indicated in green, and lamp current (Channel 4) is indicated in blue.

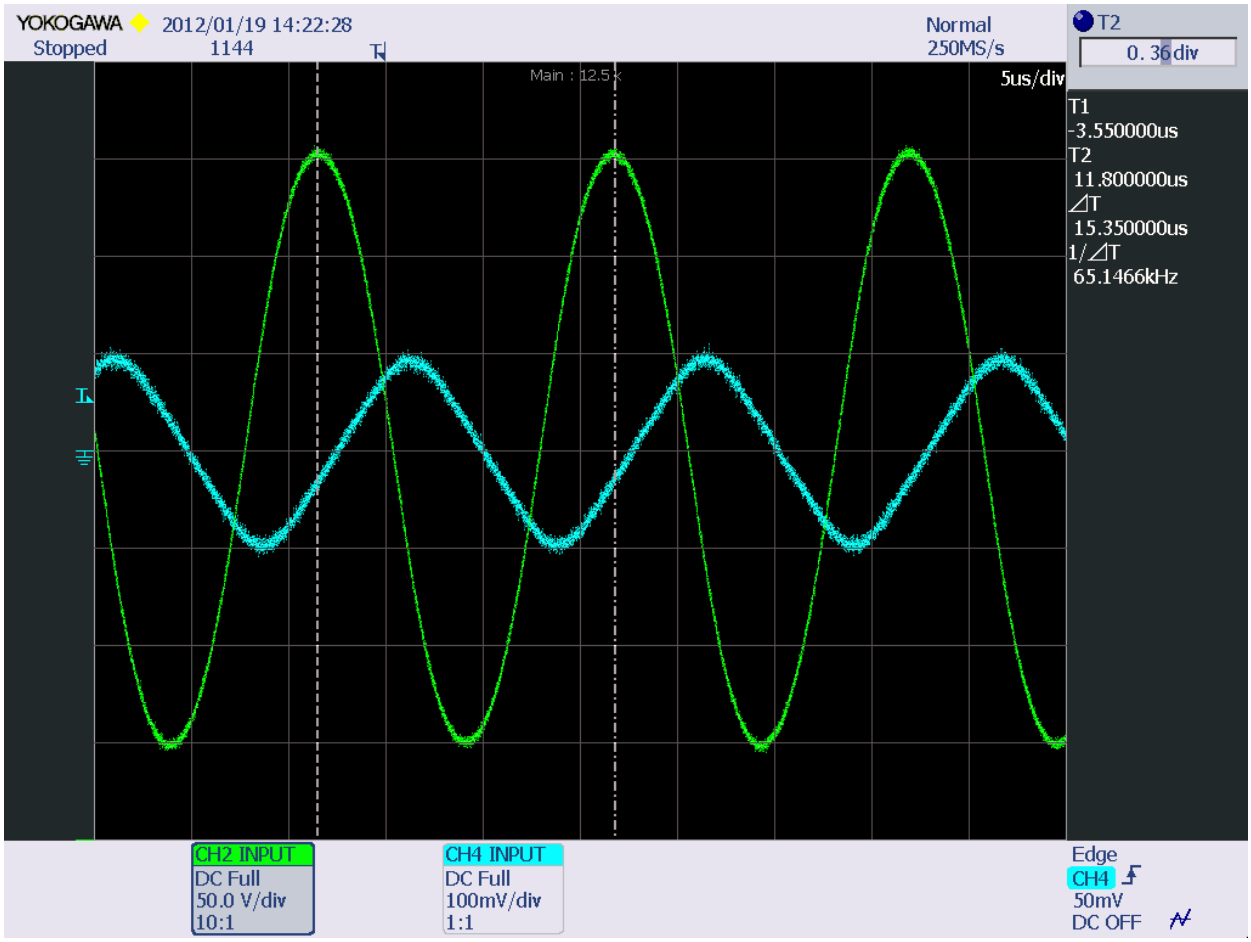

Figure 12. Fluorescent Lamp Voltage and Current at Minimum Current

Figure 13 graphs the percentage of fluorescent lamp current as a function of the number of dimming steps.

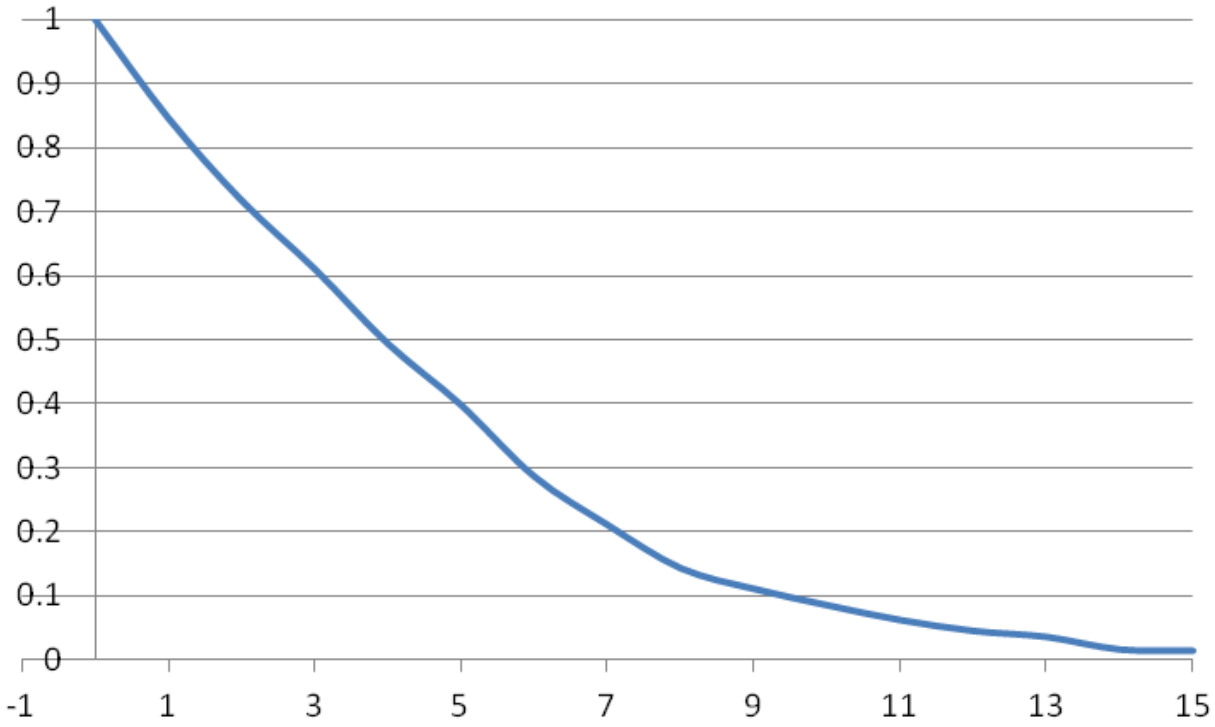

Figure 13. Fluorescent Lamp Brightness Control as a Function of Current vs. Number of Dimming Steps

Ordering Information

The products associated with this Fluorescent Ballast with ZAURA Control Reference Design are available as a kit and can be purchased from the Zilog Store – simply click the Store Product ID listed in Table 4.

Table 4. Fluorescent Ballast with ZAURA Control Reference Design Ordering Information

Part Number	Description	Store Product ID
ZRD0011F868ZRD	Fluorescent Ballast with ZAURA Control Reference Design	RD10014

Kit Contents

The Fluorescent Ballast with ZAURA Control Reference Design Kit contains the following items:

- Fluorescent Ballast Base Power Board
- ZAURA RF Wireless 868 MHz Module (affixed to the Base Board)
- ZAURA RF Remote Control device
- Two AA batteries

The ZAURA RF Wireless 868 MHz Module and the ZAURA RF Remote Control device are preprogrammed by Zilog during their manufacture.

Software and Documentation

Upon installation, the software and documentation for this reference design will be located in the following directories.

```
<Installation directory>
  \Conf
  \Docs
  \Inc
  \Lib
  \Shared
  \RD0011_Fluorescent_Ballast
    |___ PCB
```

Related Documentation

The documents associated with the Fluorescent Ballast with ZAURA Control Reference Design are listed in Table 5. Each of these documents can be obtained from the Zilog website by clicking the link associated with its Document Number.

Table 5. Fluorescent Ballast with ZAURA Control Reference Design Documentation

Document Number	Description
RD0011	This Fluorescent Ballast with ZAURA Control Reference Design document
AN0336	Getting Started with ZAURA RF Control Application Note
PUG0030	ZAURA RF Wireless Modules Product User Guide
RM0060	ZAURA RF Wireless Library Programmer's Reference Manual
UM0235	ZAURA RF Module Shell User Manual
RD0010	LED Driver with ZAURA Control Reference Design

Appendix A. Schematic Diagrams

Figure 14 presents a schematic diagram of the Fluorescent Ballast Base Power Board.

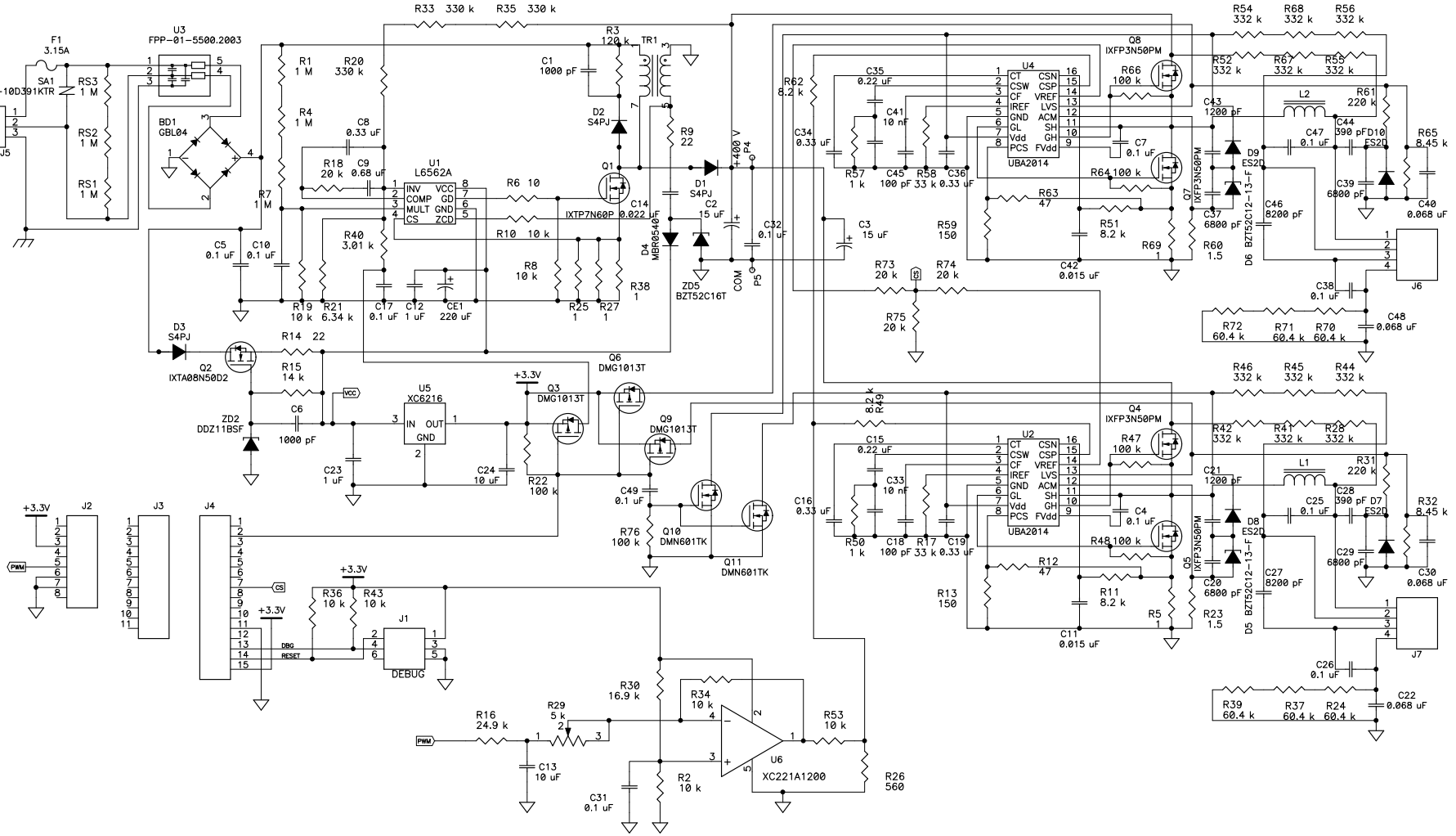

Figure 14. Fluorescent Ballast Base Power Board Schematic Diagram

Figures 15 and 16 present schematic diagrams of the ZAURA RF 868MHz Wireless Module.

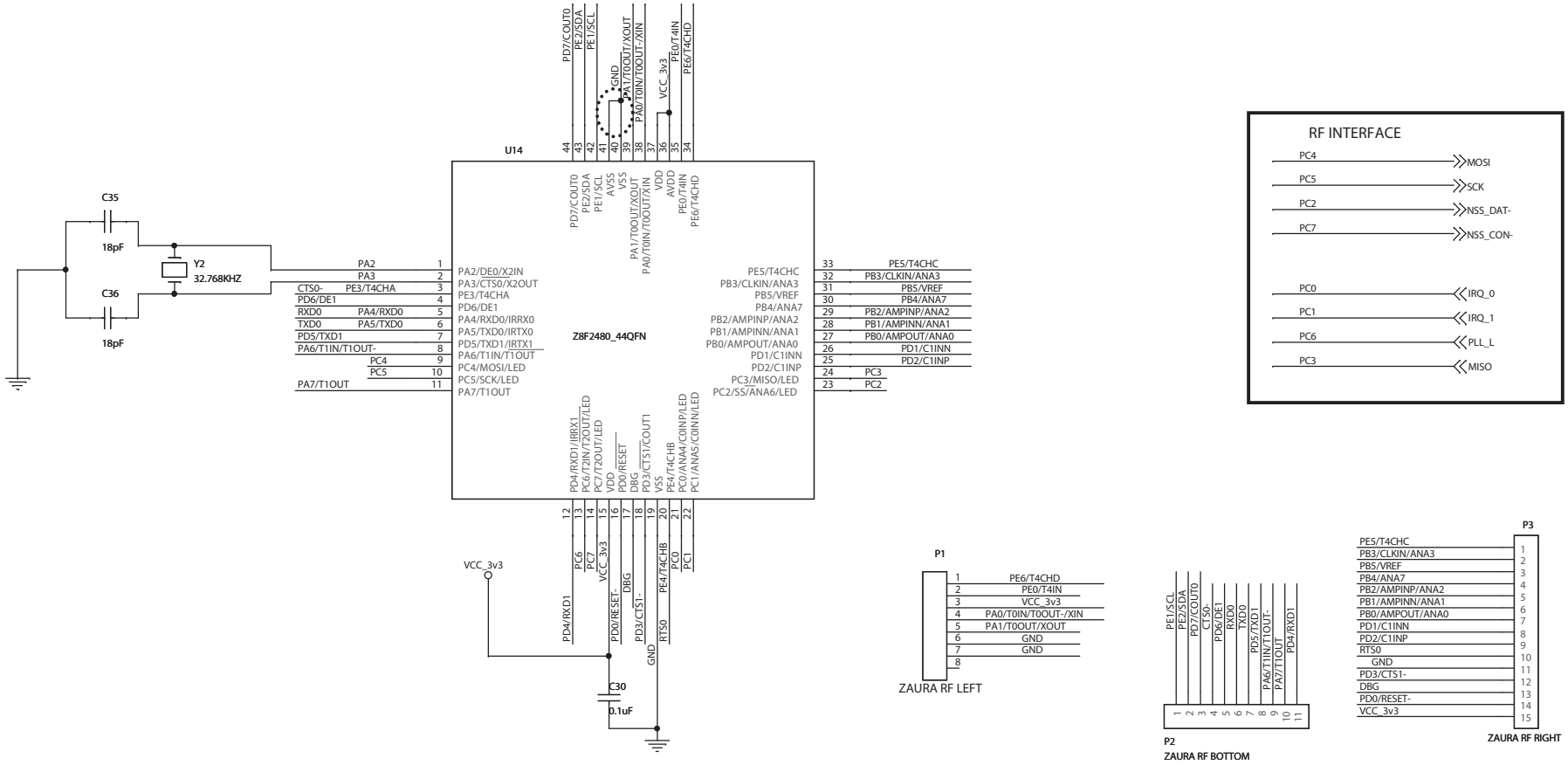

Figure 15. ZAURA RF 868MHz Wireless Module Schematic Diagram, #1 of 2

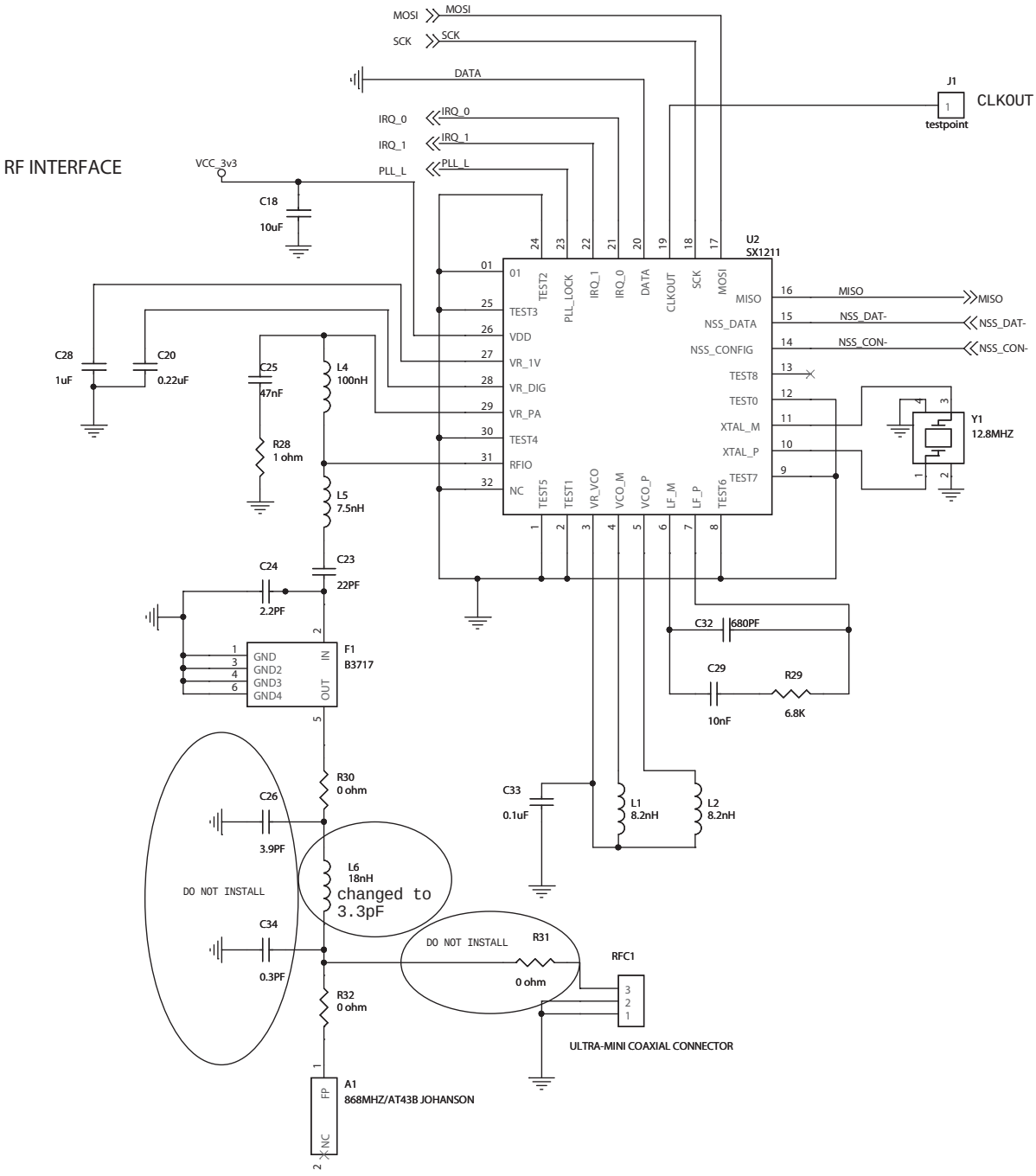

Figure 16. ZAURA RF 868MHz Wireless Module Schematic Diagram, #2 of 2

Appendix B. Fluorescent Ballast Base Power Board Assembly

Figures 17 and 18 show the locations of the components on the top and bottom sides of the Fluorescent Ballast Base Power Board, respectively.

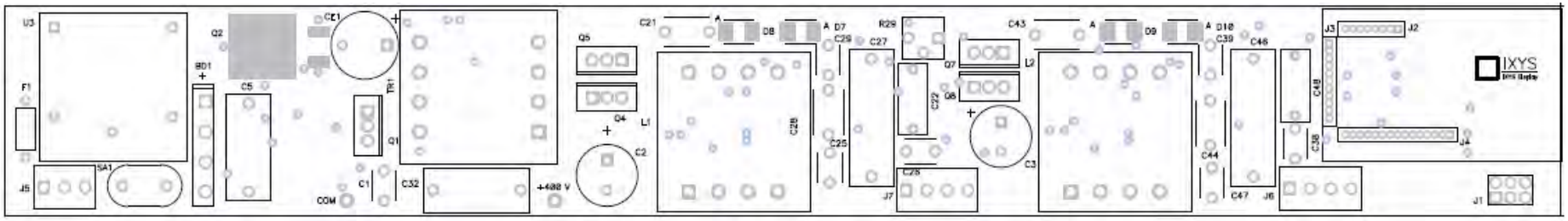

Figure 17. Location of Fluorescent Ballast Base Power Board Components, Top Layer

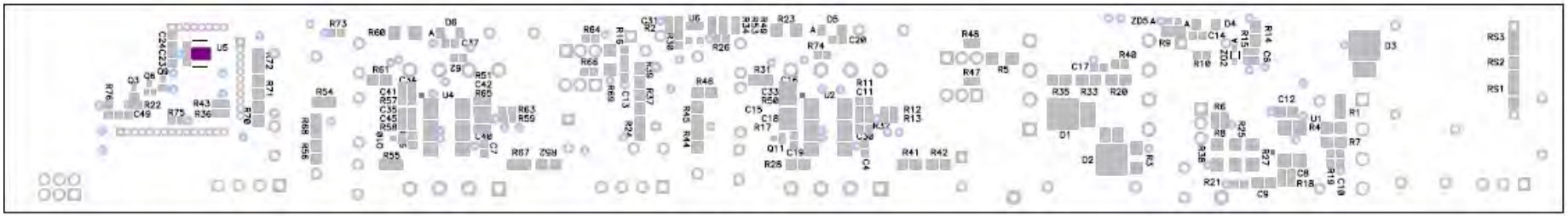

Figure 18. Location of Fluorescent Ballast Base Power Board Components, Bottom Layer

Figure 19 displays a top-side assembly diagram of the ZAURA RF Wireless Module.

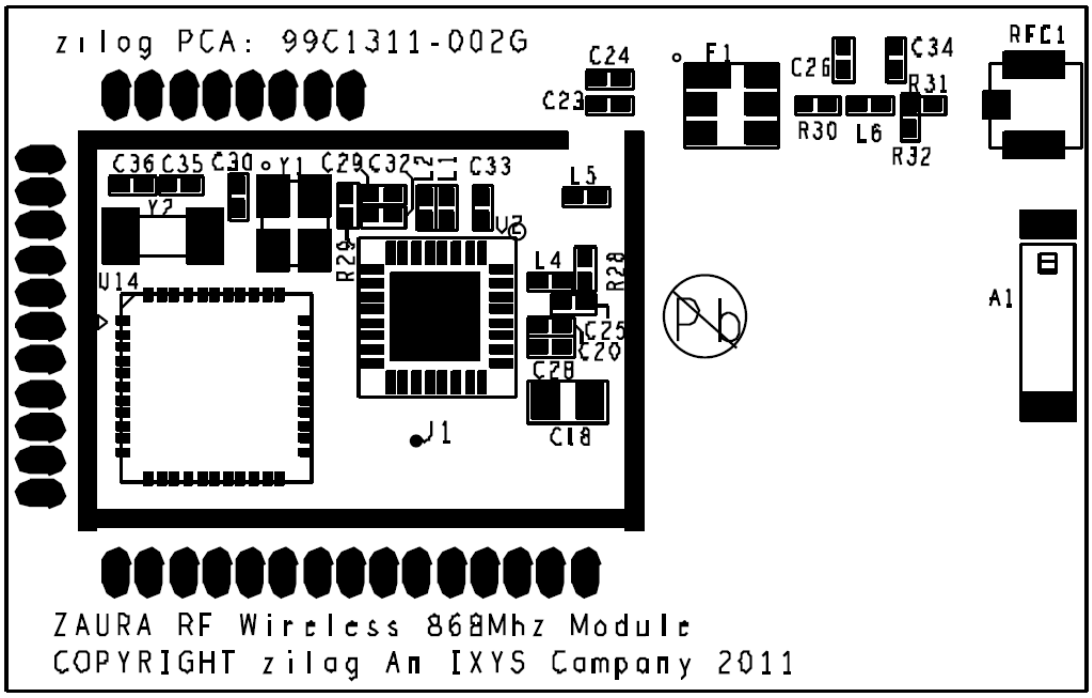

Figure 19. ZAURA RF 868MHz Wireless Module Components, Top Layer

Table 6 lists the components that comprise the Fluorescent Ballast Base Power Board.

Table 6. Fluorescent Ballast Base Power Board List of Materials

Count	Reference Designators	Value	Description	Manufacturer
1	BD1	GBL04	GBL04	Vishay
1	C1	1000pF	DEBE33A102ZC1B	Murata
2	C2, C3	15µF	EKXG451ELL150MK25S	United Chemi-Con
5	C4, C7, C10, C17, C49	0.1µF	06035C104KAT2A	AVX
2	C5, C32	0.1µF	ME104K2J150B050S	RFE International
1	C6	1000pF	06035C102KAT2A AVX	AVX
1	C9	0.68µF	0805YC684KAT2A AVX	AVX
3	C8, C19, C36	0.33µF	0603YC334KAT2A AVX	AVX
1	C12	1µF	08053C105KAT2A AVX	AVX
2	C11, C42	0.015µF	06035C153KAT2A AVX	AVX
2	C13, C24	10µF	06036C106KAT2A AVX	AVX
1	C14	0.022µF	GRM188R71H223KA01D	Murata
2	C15, C35	0.22µF	06033C224KAT2A AVX	AVX
2	C16, C34	0.33µF	06033C334KAT2A AVX	AVX
2	C18, C45	100pF	06035C101KAT2A AVX	AVX
2	C20, C37	6800pF	06035C683KAT2A AVX	AVX
2	C21, C43	1200pF	DEHR33D122KA3B	Murata
2	C22, C48	0.068µF	ECQ-E4683KF	Panasonic
1	C23	1µF	0603YC105KAT2A AVX	AVX
4	C25, C26, C38, C47	0.1µF	R82IC3100DQ60J	Kemet
2	C27, C46	8200pF	ECW-H16822JV	Panasonic
2	C28, C44	390pF	DEHR33D391KA3B	Murata
2	C29, C39	6800pF	BFC237042682	Vishay
2	C30, C40	0.068µF	06035C683KAT2A AVX	AVX
1	C31	0.1µF	0603YC104KAT2A AVX	AVX
2	C33, C41	10 nF	06033C103KAT2A AVX	AVX
1	CE1	220µF	UVZ1E221MED	Nichicon
3	D1–D3	S4PJ	Diode SP4PJ	Vishay
1	D4	MBR0540	Diode MBR0540	Diodes Inc.
2	D5, D6	BZT52C12-13-F	BZT52C12-13-F	Diodes Inc.
4	D7–D10	ES2D	ES2D	Fairchild
1	F1	3.15A	Fuse MQ 5	Bel Fuse Inc.
1	J1		Header 8624-10-89-2061	Molex

Table 6. Fluorescent Ballast Base Power Board List of Materials (Continued)

Count	Reference Designators	Value	Description	Manufacturer
1	J2		Socket Strip SMS-108-02-G-S	Samtec
1	J3		Socket Strip SMS-111-02-G-S	Samtec
1	J4		Socket Strip SMS-115-02-G-S	Samtec
1	J5		3.5mm Eurostile Low Single Row Block	Molex
2	J6, J7		3.5mm Eurostile Low Single Row Block	Molex
2	L1, L2		Z9265-B	Coilcraft
2	P4, P5		1001-0-15-01-30-02-04-0	Mill-Max
1	Q1	IXTP7N60P	IXTP7N60P	IXYS Corp.
1	Q2	IXTA08N50D2	IXTA08N50D2	IXYS Corp.
3	Q3, Q6, Q9	DMG1013T	DMG1013T	Diodes Inc.
4	Q4, Q5, Q7, Q8	IXFP3N50PM	IXFP3N50PM	IXYS Corp.
2	Q10, Q11	DMN601TK	DMN601TK	Diodes Inc.
6	R1, R4, R7, RS1–RS3	1 M	CRCW08051004FSTA Vishay	Vishay
6	R2, R8, R10, R19, R34, R53	10KΩ	CRCW06031002FSTA Vishay	Vishay
1	R3	120KΩ	CRCW12061203FSTA Vishay	Vishay
5	R5, R26, R27, R38, R69	1	CRCW12061R00FSTA Vishay	Vishay
1	R6	10	CRCW060310R0FSTA Vishay	Vishay
2	R9, R14	22	CRCW080522R0FSTA Vishay	Vishay
2	R11, R51	8.2KΩ	CRCW06038201FSTA Vishay	Vishay
2	R12, R63	47Ω	CRCW060347R0FSTA Vishay	Vishay
2	R13, R59	150Ω	CRCW0603150RFSTA Vishay	Vishay
1	R15	14KΩ	CRCW06031402FSTA Vishay	Vishay
1	R16	24.9KΩ	CRCW06032492FSTA Vishay	Vishay
2	R17, R58	33KΩ	CRCW06033302FSTA Vishay	Vishay
1	R18	20KΩ	CRCW06032002FSTA Vishay	Vishay
3	R20, R33, R35	330KΩ	CRCW08053303FSTA Vishay	Vishay
1	R21	6.34KΩ	CRCW06036341FSTA Vishay	Vishay
6	R22, R47, R48, R64, R66, R76	100KΩ	CRCW06031003FSTA Vishay	Vishay
2	R23, R60	1.5Ω	CRCW12061R50FSTA Vishay	Vishay
6	R24, R37, R39, R70, R71, R72	60.4KΩ	CRCW08056042FSTA Vishay	Vishay
1	R26	560Ω	CRCW0603560RFSTA Vishay	Vishay

Table 6. Fluorescent Ballast Base Power Board List of Materials (Continued)

Count	Reference Designators	Value	Description	Manufacturer
12	R28, R41, R42, R44, R45, R46, R52, R54, R55, R56, R67, R68	332KΩ	CRCW08053323FSTA Vishay	Vishay
1	R29	5KΩ	Potentiometer CT6EP	Copal Electronics
1	R30	16.9KΩ	CRCW06031692FSTA Vishay	Vishay
2	R31, R61	220KΩ	CRCW08052203FSTA Vishay	Vishay
2	R32, R65	8.45KΩ	CRCW06038451FSTA Vishay	Vishay
2	R36, R43	10KΩ	CRCW06031002FKTA Vishay	Vishay
1	R40	3.01KΩ	CRCW06033011FSTA Vishay	Vishay
2	R49, R62	8.2KΩ	CRCW06038201FSTA Vishay	Vishay
2	R50, R57	1KΩ	CRCW06031001FSTA Vishay	Vishay
2	R73, R74	20KΩ	CRCW06031003FSTA Vishay	Vishay
1	R75	2KΩ	CRCW06031003FSTA Vishay	Vishay
1	SA1	MOV-10D391KTR	MOV-10D391KTR	Bourns
1	TR1		Z9264-B	Coilcraft
1	U1	L6562A	L6562A	ST Micro
2	U2, U4		UBA2014T	NXP
1	U3	FPP-01-5500.2003	FPP-01 5500.2003	Schurter Electronic Components
1	U6	XC221A1200	XC221A1200	Torex
1	U9		IXVR216B332ER	IXYS Corp.
1	ZD5	BZT52C16T	BZT52C20T	Diodes Inc.
1	ZD2	DDZ11BSF	DDZ11BSF	Diodes Inc.

Table 7 lists the components that comprise the ZAURA RF 868MHz Wireless Module.

Table 7. ZAURA RF Wireless Module List of Materials

Count	Reference Designator	Value	Description	Manufacturer
1	A1	868MHz	Antenna 0868AT43B0020 ACX	Johanson Technology Inc.
1	C18	10µF	Cap, 10µF, 6.3V, X5R, 20%, Ceramic chip, 0603 SMT	TDK
1	C20	0.22µF	Cap, 0.22µF, 10V, +/-10%, X5R, Ceramic chip, 0402 SMT	Murata
1	C23	22pF	Cap, 22pF, 25V, Ceramic chip, C0G, 0402 SMT	AVX
1	C24	2.2pF	Cap, 2.2pF, 25V, Ceramic chip NP0, 0402 SMT	TDK
1	C25	47nF	Cap, 47000pF (47nF), 16V, –20%,+80%, Y5V, 0402 SMT	Murata
1	C28	1µF	Cap, 1µF, 6.3V, 10%, X5R, Ceramic chip, 0402 SMT	Murata
1	C29	10nF	Cap,10000pF(10nF), 16V, 10%, X7R, 0402 SMD	Yageo
2	C30, C33	0.1µF	Cap,0.1µF, 16V, X7R, 10%, Ceramic chip, 0402 SMT	Murata
1	C32	680pF	Cap, 680pF, 50V, +/- 5%, C0G, 0402 SMT	TDK
2	C35, C36	18pF	Cap, 18pF, 50V, Ceramic chip, 5%, C0G, 0402 SMT	TDK
1	F1		Filter Saw 866.5MHz SMD	Epcos Inc.
2	L1, L2	8.2nH	Inductor, Wire Wound, Power, 8.2nH, 0402 SMD	Murata
1	L4	100nH	Inductor, Wire Wound, RF, 100nH, 5%, 0402 SMD	Coilcraft
1	L5	7.5nH	Inductor, 7.5nH, Multilayer, 5%, 0402	TDK
1	L6	3.3pF	Cap, 3.3pF, 50V, Ceramic chip, S, 0402 UHI Q SMT	Johanson Technology Inc.
1	P1		Connector, Header/Pin, 1x8, 1.27mm, Single Row	Samtec
1	P2		Connector, Header/Pin, 1x11, 1.27mm, Single Row	Samtec
1	P3		Connector, Header/Pin, 1x15, 1.27mm, Single Row	Samtec
1	RFC1		Connector, Receptacle, Ultra-Mini Coax, SMD	Hirose Electric
1	R28	1	Resistor, 1.00Ω, 1/16W, 1%, 0402 SMD	Yageo
1	R29	6.8KΩ	Resistor, 6.8KΩ, 1/16W, 5%, 0402 SMD Vishay/Dale.	Vishay
2	R30,R32	0	Resistor, 0.0Ω, 1/10W, 0402 SMD Panasonic	ECG
1	U2		TRX 868/915/955 FSK/OOK TQFN32	Semetech
1	U14		Z8F2480_44QFN	Zilog
1	Y1		Crystal 12.8MHz, 3.2 mm X 2.5mm	Ecera
1	Y2		XTAL,32.768KHz, SMD, 12.5pF	Abracon Corp.

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