Reference Design

AC Power Switching Relay with ZAURA Control

RD001902-0814

Overview

This reference design integrates Zilog's ZAURA RF 868 MHz Wireless Module onto an AC power switching relay designed to showcase the features and performance of a relay-based switch with AC voltage zero-crossing detection to minimize surge currents. This reference design can be used as a basis for developing systems that can control different power installations.

On its own, without the ZAURA RF Wireless Module attached, the AC power switch functions as a demonstration board, providing current to power the ZAURA RF Wireless Module and relay. However, the AC power switch cannot control load, because the source of the on/off pulses required to perform this operation is generated by the Z8F2480 MCU on the RF Module. In combination, the Power Board with the Module attached, all controlled by a hand-held remote control device, enable RF communication to turn the load on and off.

For purposes of demonstrating RF control, a hand-held ZAURA RF Remote Control device is also included with this reference design. See the Remote Control Operation section on page 7 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 868 MHz 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 AC Power Switching Relay with ZAURA Control reference design includes the following features:

- 90–240 V AC RMS input voltage range
- Up to 10 A load current
- Less than 2 mA standby current at 120 V AC when in an ON or OFF state
- 868 MHz Wireless Module operating frequency

Potential Applications

The AC Power Switching Relay 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 lighting control without wiring or infrastructure changes

Discussion

The AC Power Switch Demonstration Board is simply comprised of the AC Power Switch Base Power Board (Power Board) with Zilog's ZAURA RF Wireless Module affixed to it, as shown in Figure 1 (the Module is located in the center of the figure). The Power Board is a two-layer surface mount board that provides easy probe access points to all AC Power Switch 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. AC Power Switching Relay with ZAURA Control Demonstration Board

The Power Board and attached ZAURA Module are powered from a single-phase AC line with a 90–240 V voltage range. The AC Power Switch Base Power Board provides up to 10 A load current at 240 V AC RMS.

The Board and Module are contained in a housing assembly with a female 3-prong extension cord; see Figure 2.

Figure 2. AC Power Switching Relay Assembly

The dimensions of the Power Board are 2.85 (L) x 1.85" (W) x 0.7" (H). A block diagram of the Board is shown in Figure 3.
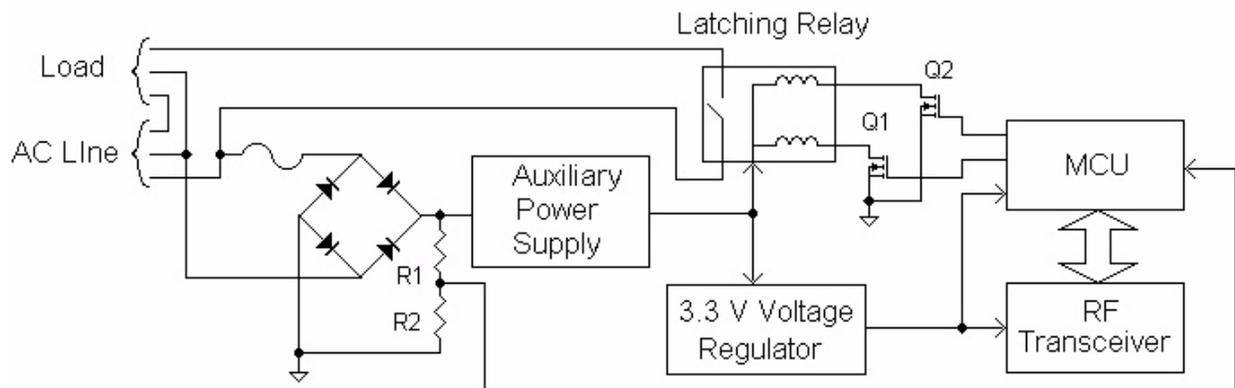

Figure 3. AC Power Switching Relay with ZAURA Control Demonstration Board Block Diagram

⚠️ **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 400 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.

AC Power Switch Base Power Board

The AC Power Switch Base Power Board, shown in Figure 4, contains an auxiliary power supply with a depletion-mode MOSFET Q1 (IXTA08N50D2), a Zener diode ZD1, and resistors R1 and R2, which provide approximately 13 V to drive latching relay K1, as well as voltage regulator U1 with 3.3 V output to drive MCU and RF block.

For further reference, see the schematic diagram of the AC Power Switch Base Power Board in Figure 11 on page 15.
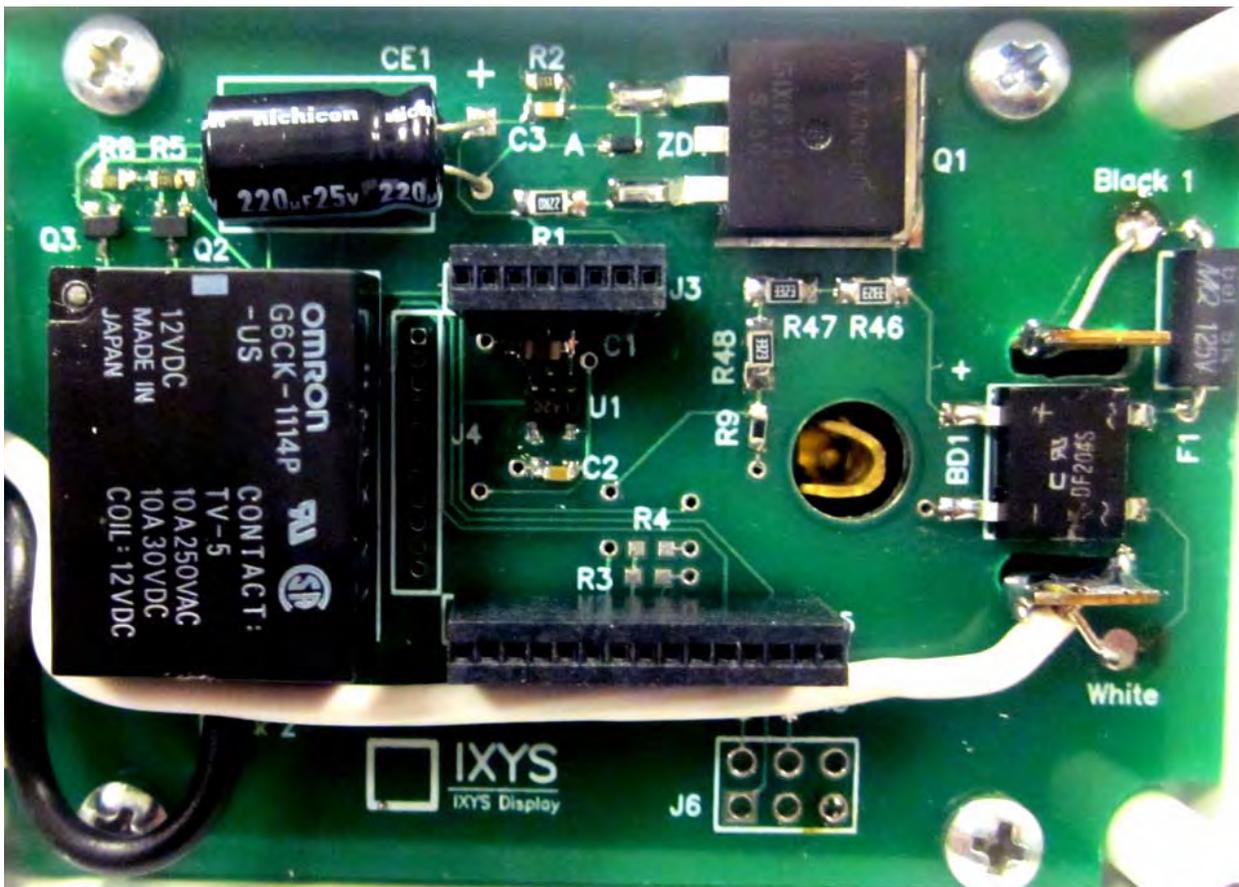

Figure 4. AC Power Switch Base Power Board, Top View

MOSFETs Q2, Q3 connected to SET/RESET relay K1 coils change relay state after pulse from MCU received.

Resistive divider R46–R48/R9 provides signal to MCU internal comparator to determine moment of AC zero crossing.

Debug connector J6 is for factory use only and not assembled on the board.

ZAURA RF Wireless Module

The ZAURA RF Wireless 868 MHz Module, shown in Figure 5, features a Z8F2480 MCU[1] 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).
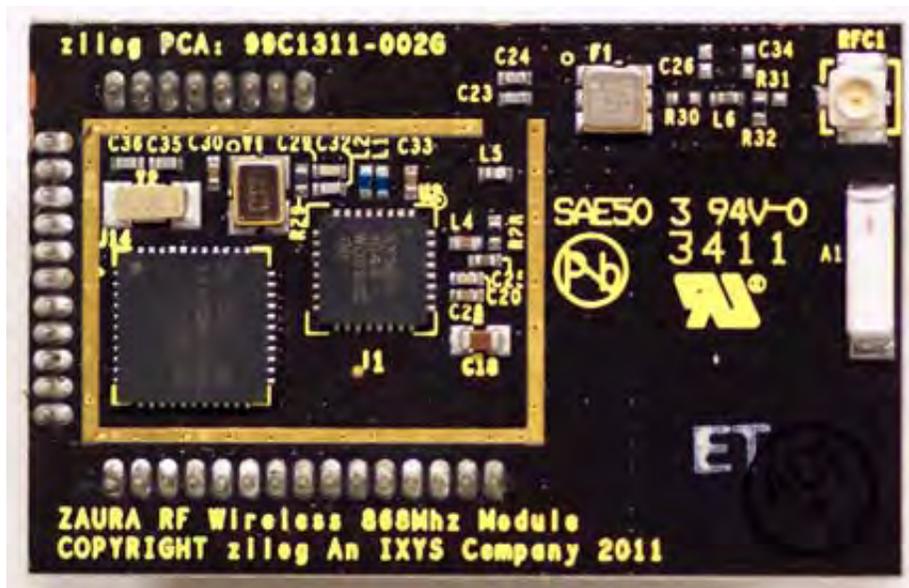

Figure 5. ZAURA RF Wireless Module

Principles of Operation

After power-up, auxiliary power supply provides approximately 13 V to start the 3.3 V voltage regulator and to power the MCU. As soon as the MCU becomes active, it begins monitoring for voltage drops at resistor R9. The MCU determines the time period between two consecutive internal comparator high-to-low and low-to-high transitions to detect an AC zero crossing point, and determines two high-to-low transitions to determine the AC

---

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

frequency. The MCU next generates a pulse that turns relay K1 ON (its default state). The relay will remain in this ON state, and the MCU's RF block will remain in Standby Mode until it is commanded to turn OFF via the remote control unit.

If this turn-off command is recognized, the MCU will again determine the nearest AC zero crossing point, and will turn the relay OFF, albeit with a corresponding delay to compensate for relay switching time. This sequence allows the active load to turn on or off at the exact moment when the AC voltage crosses the zero point and the load current is zero, which results in a minimized load surge current.

The MCU goes into Standby Mode after every command execution to minimize power consumption. It wakes up approximately every 200ms to monitor commands from the remote control unit. If no command is recognized, the MCU returns to STANDBY Mode.

Setup, Configuration and Use

This section describes how to set up, configure and operate the AC Power Switching Relay 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 400V). 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 AC Power Switch Demonstration Board

The Base Power Board should be powered from a single-phase AC source with a voltage range of 90V–240V 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 power switch should be connected to an American standard wall receptacle, while the load, which must be equipped with an American standard 3-prong plug, connects to the opposite end of the assembly's extension cord; see for reference.

The Base Power Board wakes up and loads with a delay period of approximately 0 to 1.5 seconds, depending on its previous relay state.

Remote Control Operation

The ZAURA RF Remote Control unit, shown in Figure 6, is the hand-held RF remote control device that conveniently controls the ZAURA RF Module.

Figure 6. Hand-Held ZAURA RF Remote Control Device

> ▶ **Note:** The remote unit's unlabeled buttons currently do not function; they are 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. Connect the AC Power Switch Demonstration Board to an AC line. The load will turn ON by default.

3. Use the **ON/OFF** button to turn the load on and off. 4.The other buttons on the remote do not perform any functions for this application.

AC Power Switch 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 50 kbps data rate, a binary FSK signal centered at 866.2 MHz with a 100 KHz frequency deviation and a modulation index of 4). This configuration ensures that commands sent by the remote can be received by the AC Power Switch.

After the radio has been configured, the AC Power Switch is activated (i.e., the relay is turned ON). The software then 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 Control.

Approximately every 220 ms, 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 22 ms 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 220 ms 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 relay signal, as appropriate.

Every time the ON/OFF button on the ZAURA RF remote is pressed, it transmits 11 small RF packets (each less than 2 ms in duration) every 20 ms, matching the receive periodicity of the AC Power Switch software.

Viewing and Rebuilding the RF Module Software

The source code file provided with this AC Power Switching Relay 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 868 MHz 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 AC Power Switch project requires that you use the ZDS II – 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 ZDS II.

3. Launch the ZDS II – 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 `RD0019_AC_Power_Switching_Relay` folder which, by default, is located in the following path:

   `C:\Program Files\Zilog\ZAURA_RF_Wireless_<version_number>\`
   `RD0019_AC_Power_Switching_Relay`

6. Select the `AC_Switch.zdsproj` file from the `RD0019_AC_Power_Switching_Relay` 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 ZDSII toolbar. This menu is highlighted in red in Figure 7.
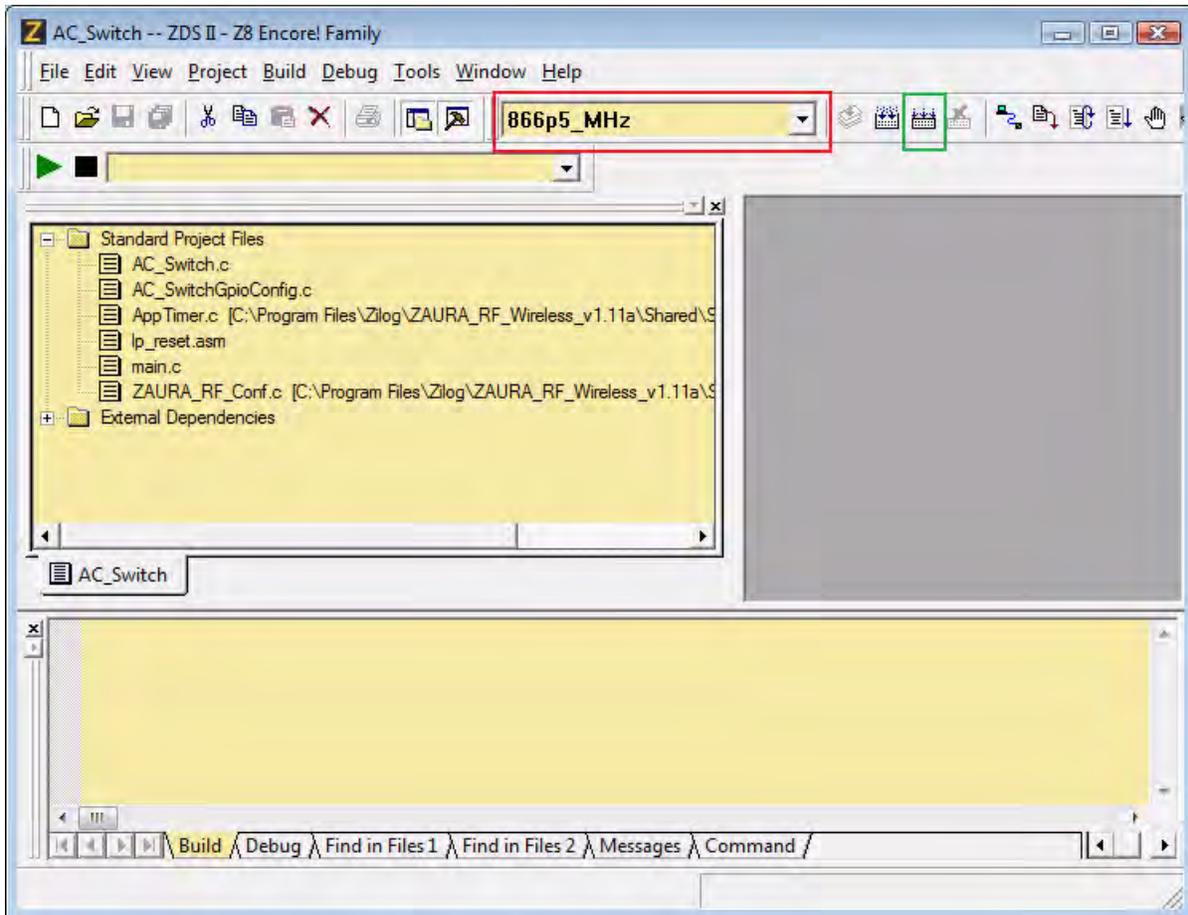

Figure 7. Build Mode Configuration

8. Click the **Rebuild All** toolbar icon, which is highlighted in green in Figure 7.

9. When the rebuild is complete, a `Build succeeded.` message will appear, as high-lighted in Figure 8.
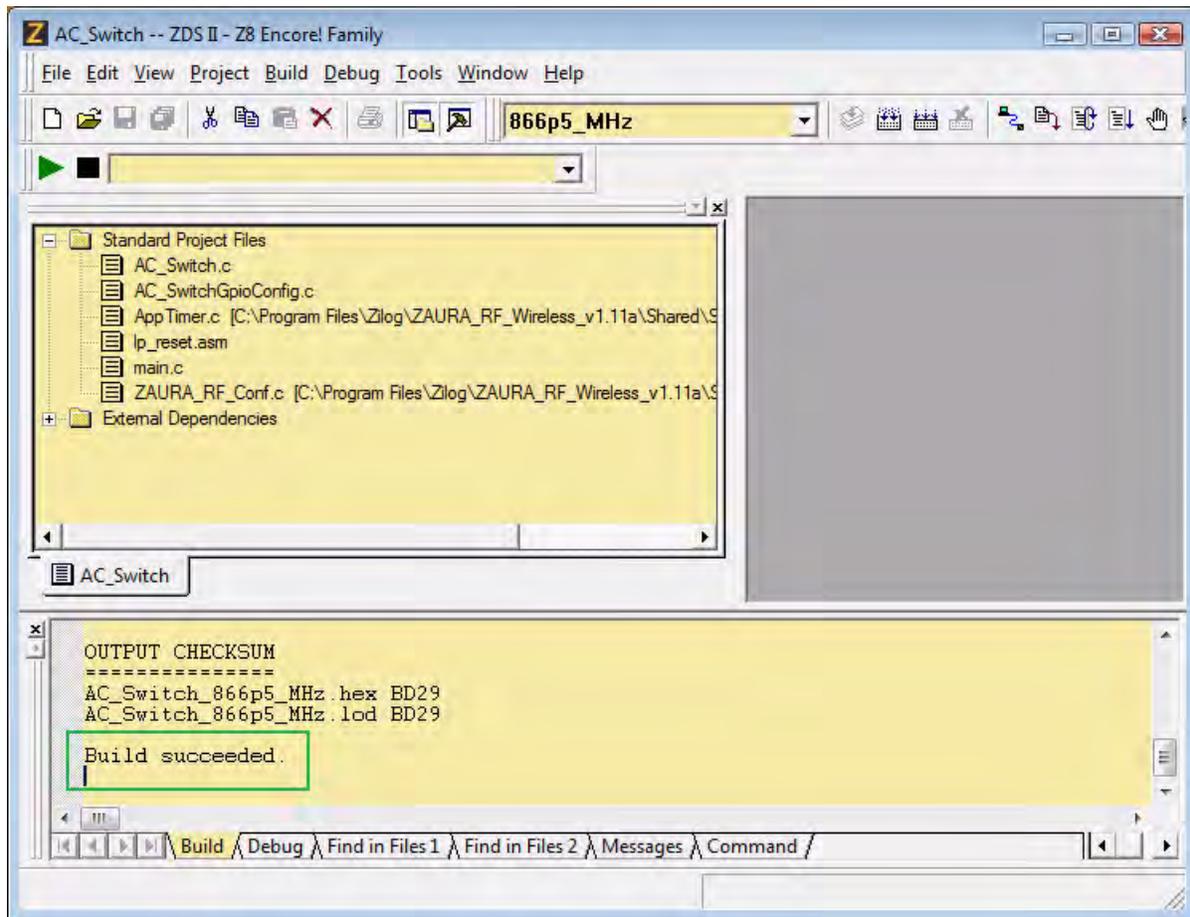

Figure 8. A Successful Build

Electrical Specifications

This section describes the electrical characteristics of the AC Power Switch Demonstra-tion Board. The data that follows describes the electrical characteristics of the AC Power Switch 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 condition 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	10	A
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	90–240	V
Ambient temperature range	−20 to +45	°C

Table 3. Electrical Parameters

Name	Conditions	Min	Typ	Max	Units
Standby mode input current	120V RMS		2		mA
RF remote control device operating frequency			866.2		MHz
RF remote control device operating distance			30		m

Waveforms

The following two figures show waveforms for the operation of the Base Power Board.
Figure 9 presents a waveform image of the AC Power Switch when it executes the ON
command. This image superimposes 50 curves, and essentially shows that the load current
starts at the AC zero crossing point. These waveforms are defined as:

Yellow. Channel 1: relay ON pulse.

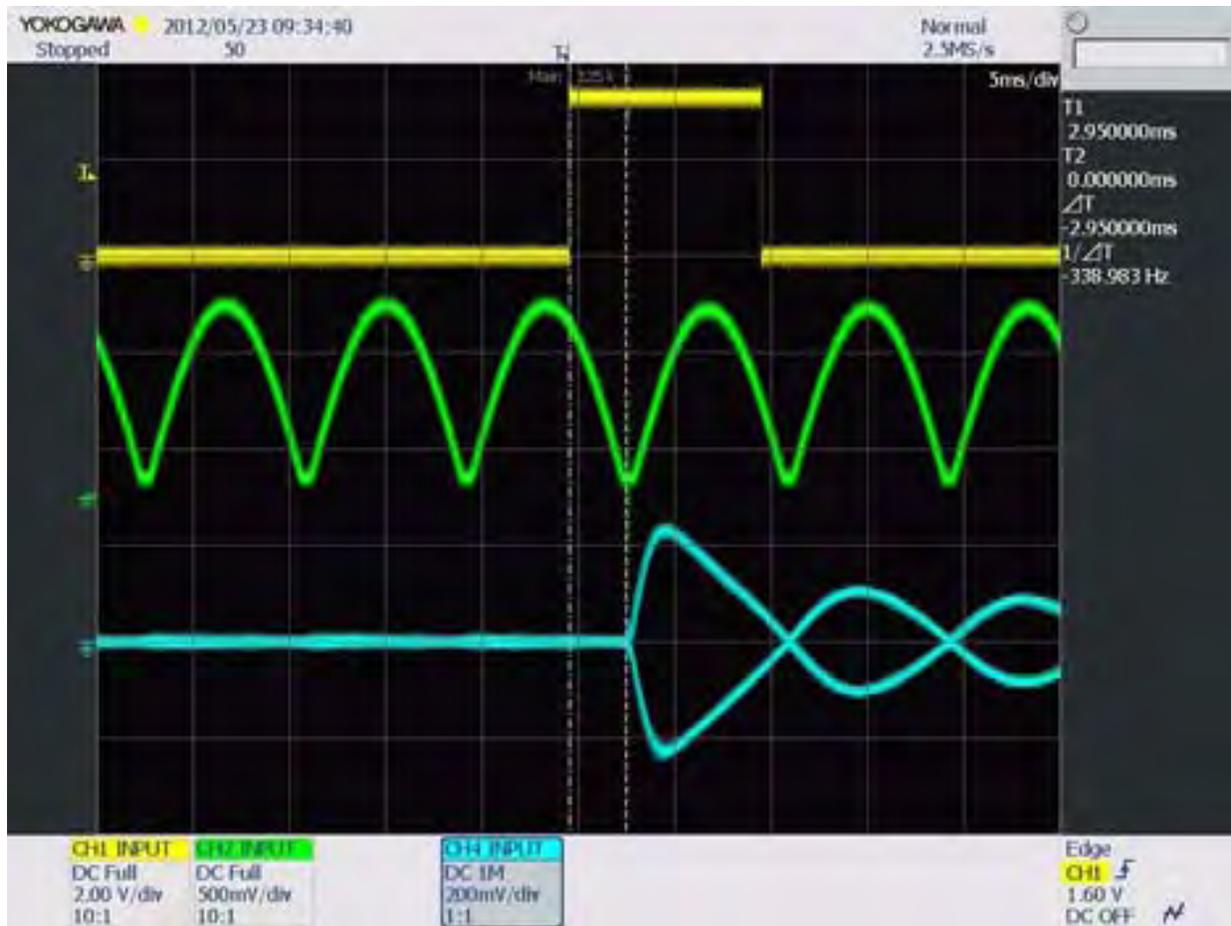**Green.** Channel 2: rectified AC voltage drop at R9 (comparator input).

Blue. Channel 4: load current.

Figure 9. AC Power Switch Executes the ON Command

Figure 10 presents a waveform image of the AC Power Switch when it executes the OFF
command. This image also superimposes 50 curves, and essentially shows that the load
current stops at the AC zero crossing point. In Figure 10, the waveforms are defined as:

Yellow. Channel 1: relay OFF pulse.

Green. Channel 2: rectified AC voltage drop at R9 (comparator input).

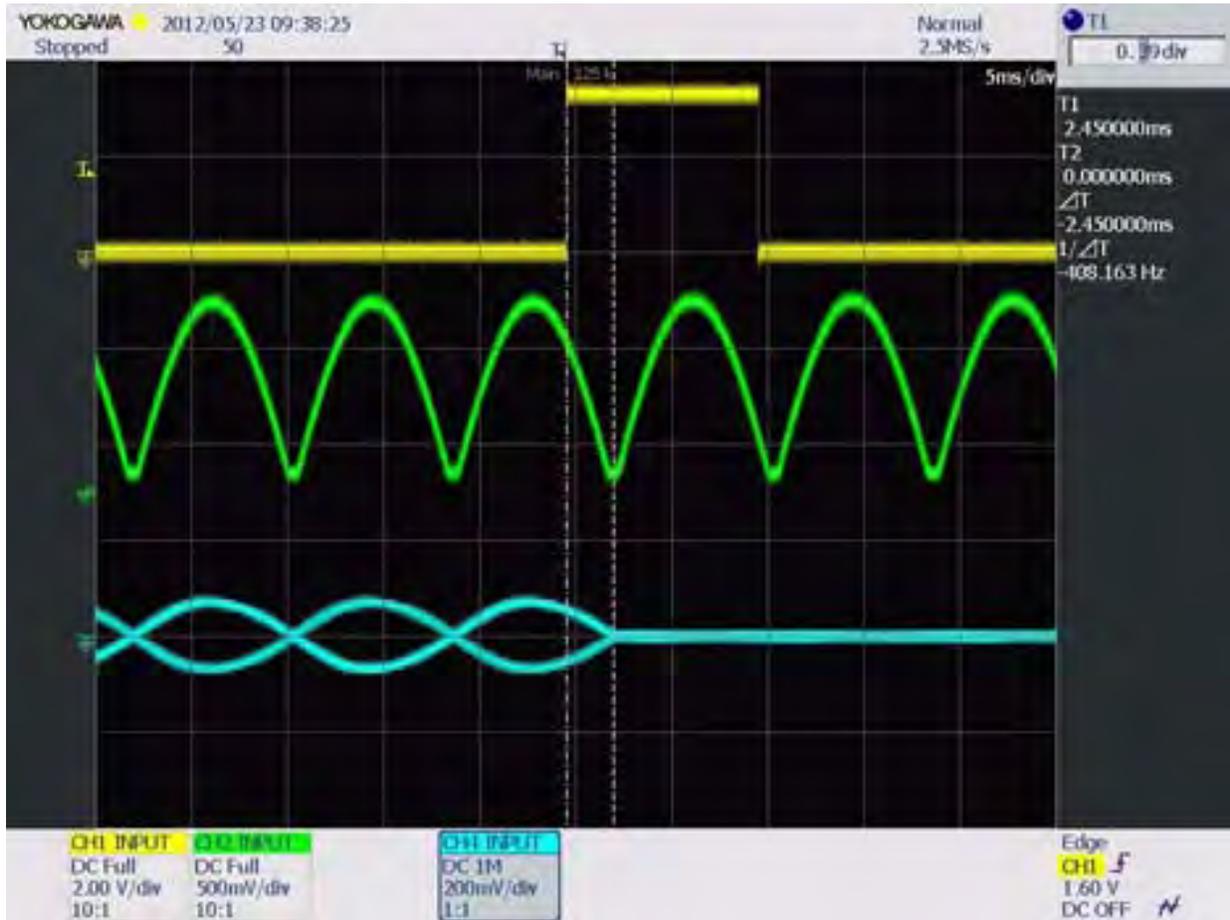**Blue.** Channel 4: load current.

Figure 10. AC Power Switch Executes the OFF Command (50 commands in series)

Ordering Information

The products associated with this AC Power Switching Relay 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. AC Power Switching Relay with ZAURA Control Reference Design Ordering Information

Part Number	Description	Store Product ID
ZRD0019F868ZRD	AC Power Switching Relay with ZAURA Control Reference Design	RD10016

Kit Contents

The AC Power Switching Relay with ZAURA Control Reference Design Kit contains the following items:

- AC Power Switch Base Board assembly with a female 3-prong extension cord
- 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
  \RD0019_AC_Power_Switching_Relay
    |___ PCB
```

Related Documentation

The documents associated with the AC Power Switching Relay 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. AC Power Switching Relay with ZAURA Control Reference Design Documentation

Document Number	Description
RD0019	This AC Power Switching Relay 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
RD0011	Fluorescent Ballast with ZAURA Control Reference Design

Appendix A. Schematic Diagrams

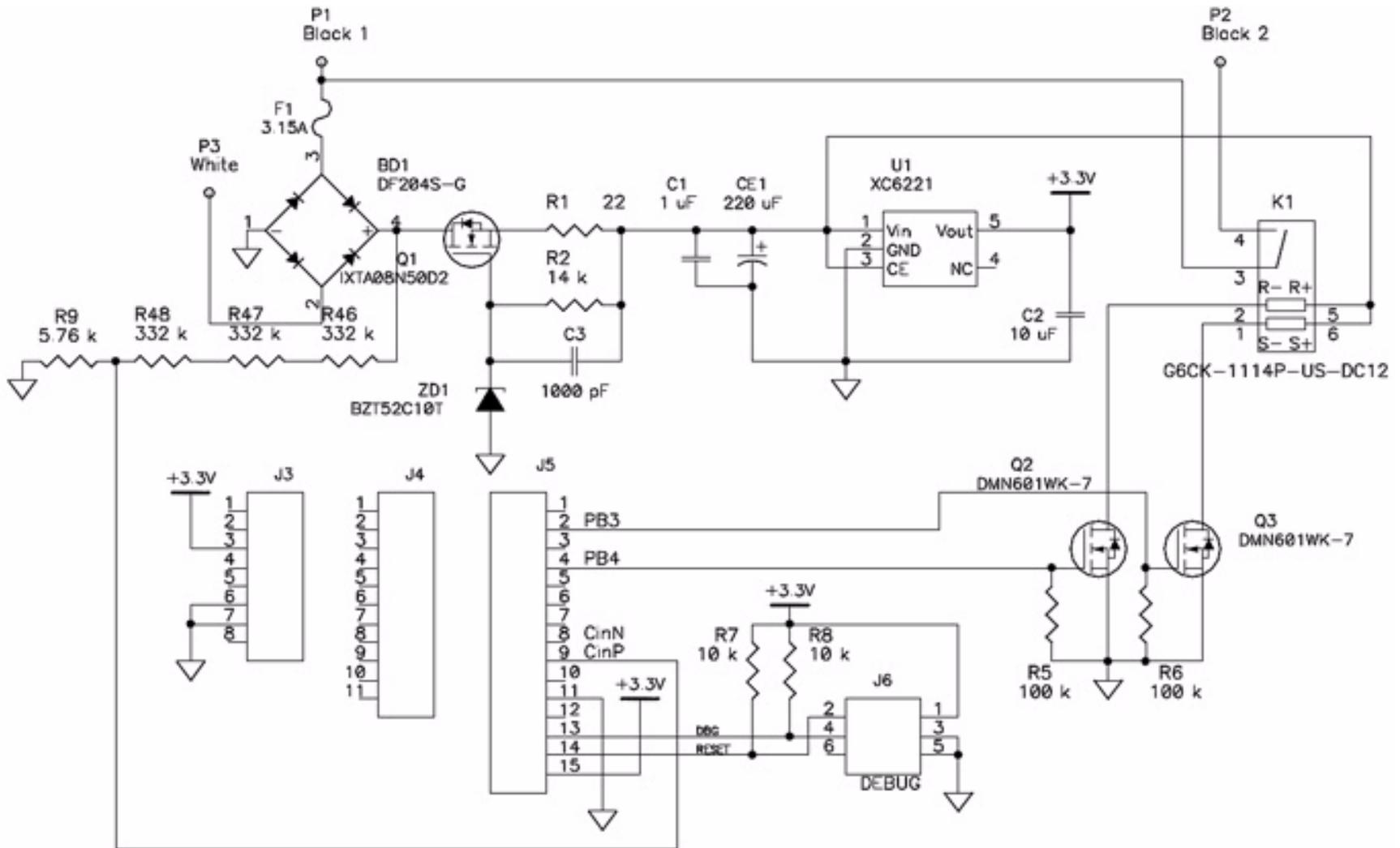Figure 11 presents a schematic diagram of the AC Power Switch Base Power Board.

Figure 11. AC Power Switch Base Power Board Schematic Diagram

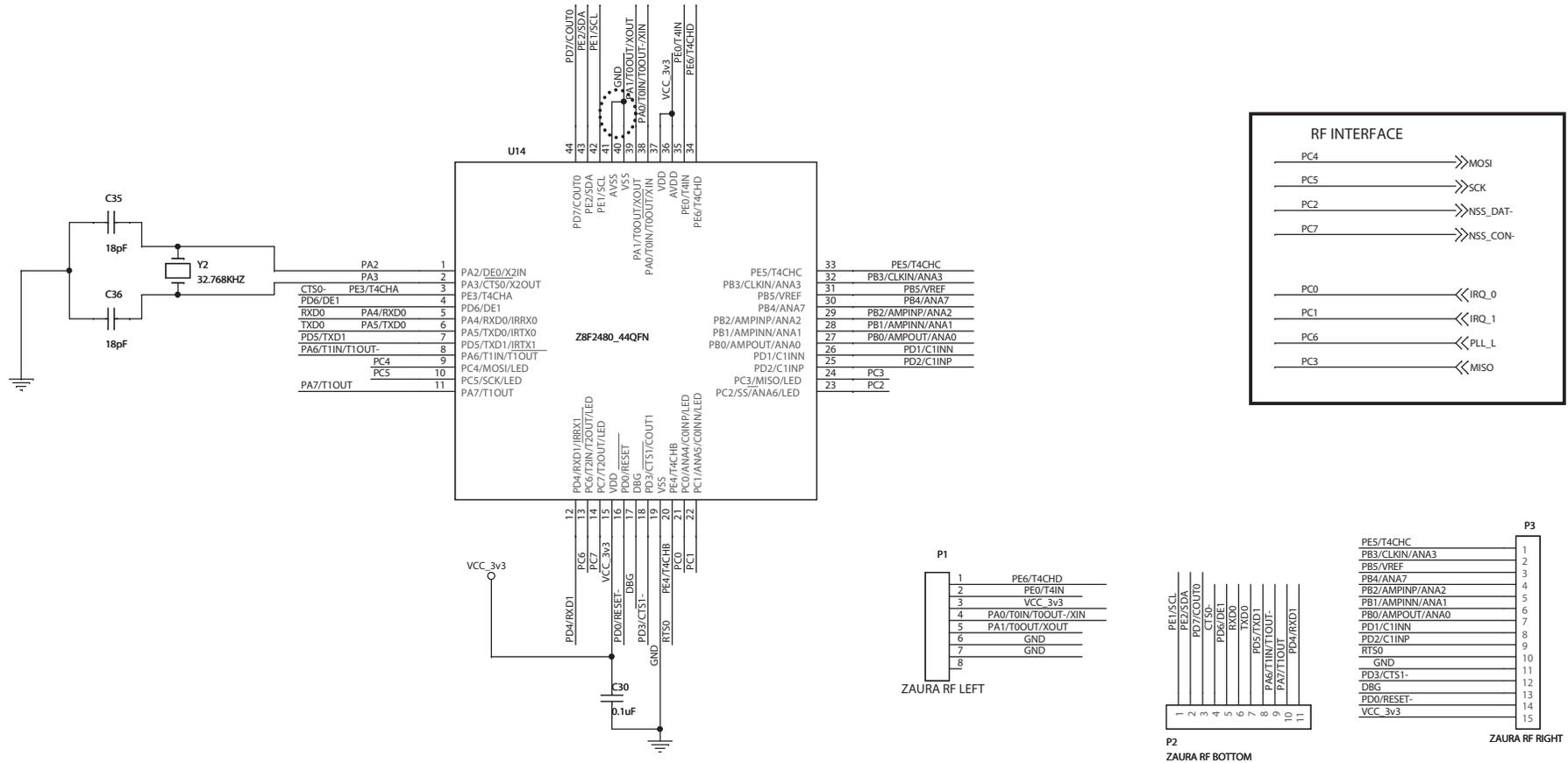Figures 12 and 13 present schematic diagrams of the ZAURA RF 868 MHz Wireless Module.

Figure 12. ZAURA RF 868 MHz Wireless Module Schematic Diagram, #1 of 2

RF INTERFACE
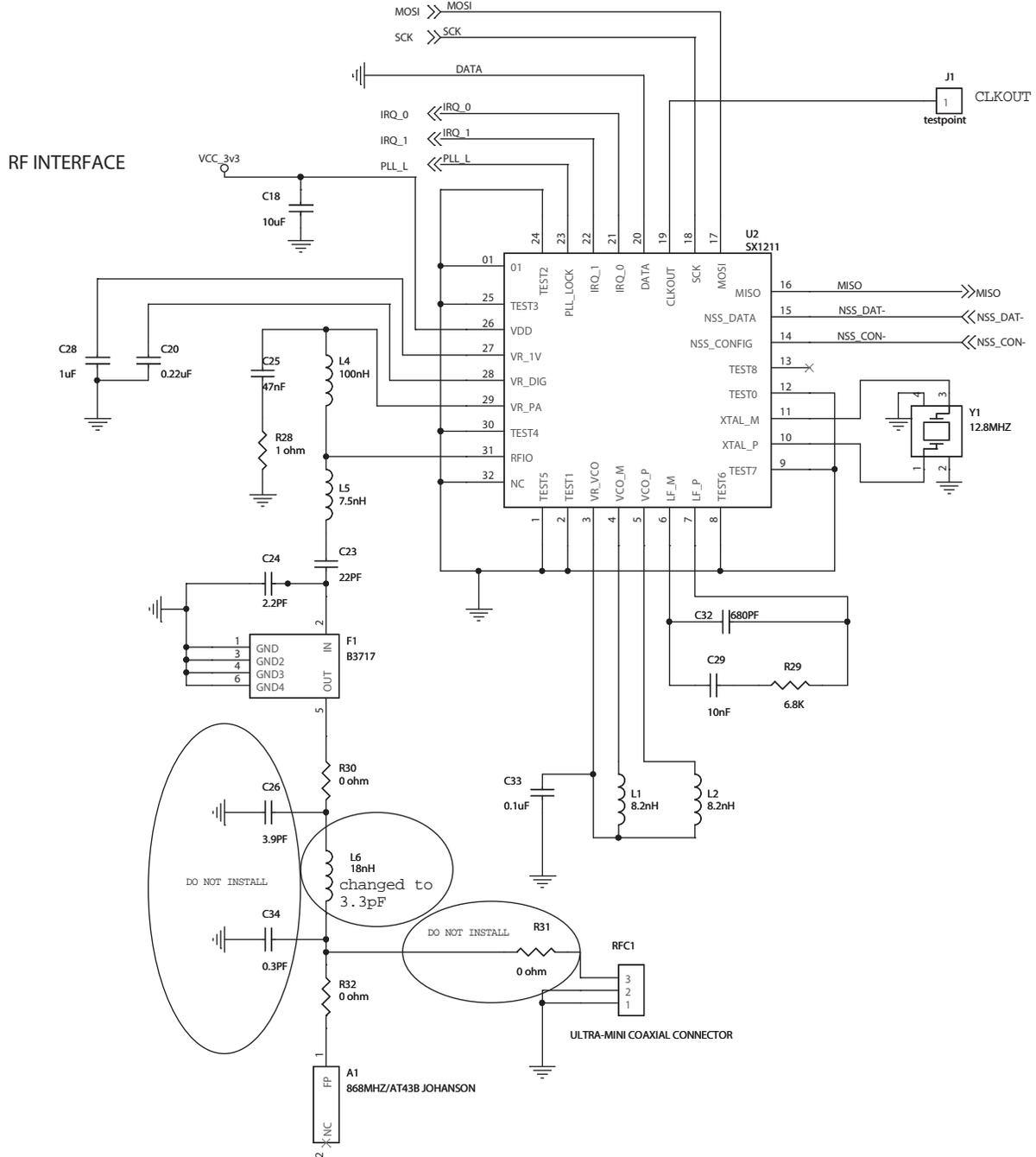
Figure 13. ZAURA RF 868 MHz Wireless Module Schematic Diagram, #2 of 2

Appendix B. AC Power Switch Base Power Board Assembly

Figure 14 shows the locations of the components on the top of the AC Power Switch Base Power Board.

Figure 14. Location of AC Power Switch Base Power Board Components, Top Layer

Figure 15 displays a top-side assembly diagram of the ZAURA RF Wireless Module.
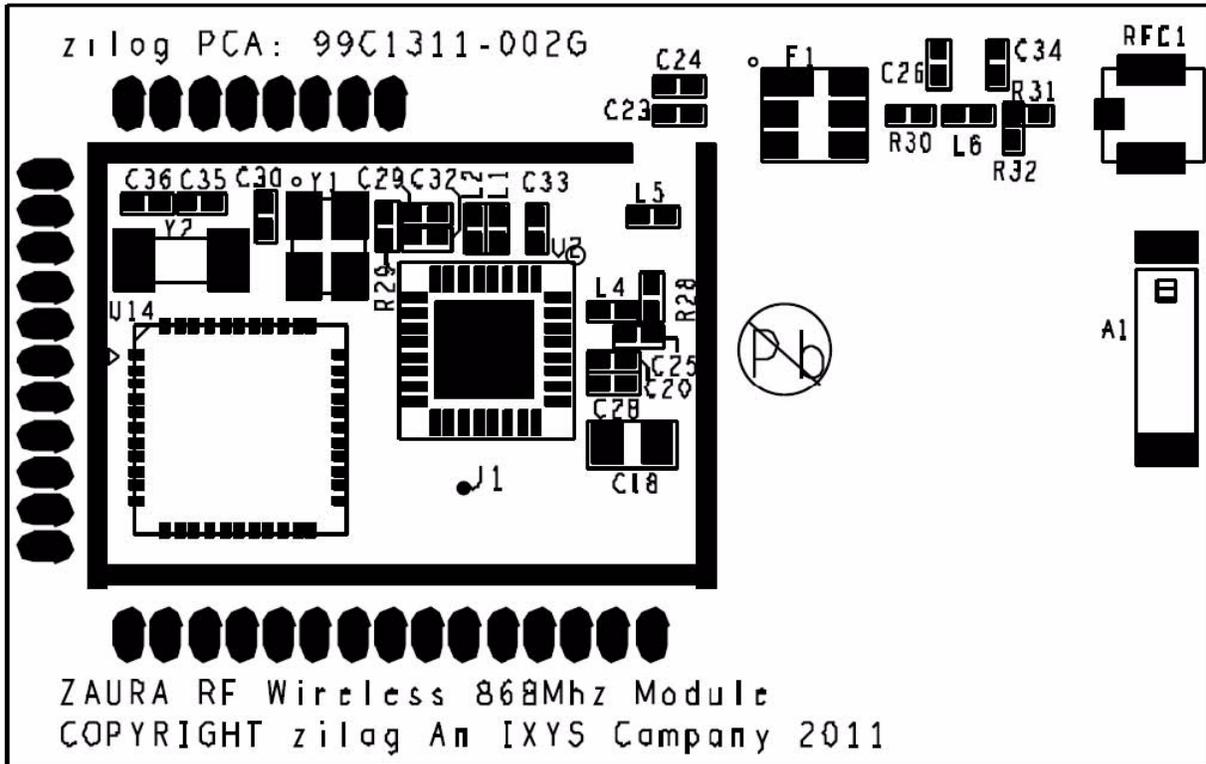
Figure 15. ZAURA RF 868MHz Wireless Module Components, Top Layer

Table 6 lists the components that comprise the AC Power Switch Base Power Board.

Table 6. AC Power Switch Base Power Board List of Materials

Count	Reference Designator	Value	Description
1	BD1	DF204S-G	DF204S-G Comchip Technology
1	CE1	220 µF	UVY1E221MED Nichicon
1	C1	1 µF	08053C105KAT2A AVX
1	C2	10 µF	06036C106KAT2A AVX
1	C3	1000 pF	06035C102KAT2A AVX
1	F1	3.15A	Fuse MQ 5 Bel Fuse Inc.
1	J3		Socket Strip SMS-108-02-G-S Samtec
1	J4		Socket Strip SMS-111-02-G-S Samtec
1	J5		Socket Strip SMS-115-02-G-S Samtec
1	J6		Header 8624-10-89-2061 Molex
1	K1		G6CK-1114P-US-DC12 Omron
1	Q1	IXTA08N50D2	IXTA08N50D2 IXYS Corp.
2	Q2, Q3	DMN601WK-7	DMN3150LW Diodes Inc.
1	P1–P3		1001-0-15-01-30-02-04-0 Mill-Max
1	R1	22	CRCW080522R0FSTA Vishay
1	R2	14 k	CRCW06031402FSTA Vishay
2	R5, R6	100 k	CRCW06031003FSTA Vishay
2	R7, R8	10 k	CRCW06031002FKTA Vishay
1	R9	5.76 k	CRCW06031402FSTA Vishay
3	R46, R47, R48	332 k	CRCW08053323FSTA Vishay
1	U1		XC6221B332MR-G Torex Semiconductor Ltd.
1	ZD1	BZT52C10T	BZT52C10T 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.

Customer Support

To share comments, get your technical questions answered, or report issues you may be experiencing with our products, please visit Zilog's Technical Support page at http://support.zilog.com.

To learn more about this product, find additional documentation, or to discover other facets about Zilog product offerings, please visit the Zilog Knowledge Base at http://zilog.com/kb or consider participating in the Zilog Forum at http://zilog.com/forum.

This publication is subject to replacement by a later edition. To determine whether a later edition exists, please visit the Zilog website at http://www.zilog.com.

To learn more about this product, find additional documentation, get your technical questions answered or report issues, please contact esales@zilog.com.

Warning: DO NOT USE THIS PRODUCT IN LIFE SUPPORT SYSTEMS.

LIFE SUPPORT POLICY

ZILOG'S PRODUCTS ARE NOT AUTHORIZED FOR USE AS CRITICAL COMPONENTS IN LIFE SUPPORT DEVICES OR SYSTEMS WITHOUT THE EXPRESS PRIOR WRITTEN APPROVAL OF THE PRESIDENT AND GENERAL COUNSEL OF ZILOG CORPORATION.

As used herein

Life support devices or systems are devices which (a) are intended for surgical implant into the body, or (b) support or sustain life and whose failure to perform when properly used in accordance with instructions for use provided in the labeling can be reasonably expected to result in a significant injury to the user. A critical component is any component in a life support device or system whose failure to perform can be reasonably expected to cause the failure of the life support device or system or to affect its safety or effectiveness.

Document Disclaimer