APPLICATION NOTE

AT06412: Real Color ZLL LED Light Bulb with ATmega256RFR2 – Hardware User Guide

Atmel AVR 8-bit Microcontroller

Description

The reference design of the Real Color ZLL LED Light Bulb is developed to demonstrate ZLL (ZigBee® Light Link) protocol functions. The reference hardware includes four parts; AC to DC power supply, Atmel single-chip RF MCU, LED drive circuit, and LED String board. The LED string is controlled by application software on Tablet or Smartphone via the ZigBee Light Link protocol commands through the Atmel® ATmega256RFR2. The Real Color ZLL LED Light Bulb supports to color switch, tunable brightness, and so on.

For this reference design, the hardware design files (schematic, BOM, and PCB Gerber) and software source code can be downloaded from the Atmel website. The provided hardware documentation can be used with no limitations to manufacture the reference hardware solution for the design.

Features

- Atmel AVR® ATmega256RFR2 microcontroller with 2.4GHz radio transceiver
- Drives three parallel high power LED strings (Red, Green, Blue)
- Up to 420mA current for each LED string with individual PWM
- 1kHz PWM input for Dimming Duty Cycle
- 8W AC to DC power supply
- Over–Temperature Detection
- E27 Standard Lamp interface
- Programming/Debugging interface: JTAG, UART

Figure 1. Real Color ZLL LED Light Bulb.

Table of Contents

1. Related Items

The following list contains links to the most relevant documents for the ZLL Bulb with Atmel ATmega256RFR2.

- Atmel MCU Wireless Atmega256RFR2/ Atmega128RFR2/ Atmega64RFR2 Summary Datasheet
  The document contains complete and detailed description of all modules included in the Atmel MCU wireless microcontroller family.
- Atmel MCU Wireless Atmega256RFR2/ Atmega128RFR2/ Atmega64RFR2 Datasheet
  ATmega256RFR2 is the microcontroller used in this solution.
- RCB256RFR2 – Hardware User Manual
  The document describes the usage, design, and layout of the Atmel ATmega256RFR2 radio controller board.
- Atmel Studio 6
  Atmel Studio 6 is a free Atmel IDE for development of C/C++ and assembler code for Atmel microcontrollers.
- Atmel JTAGICE3
  JTAGICE3 is a mid-range development tool for Atmel AVR 8- and 32-bit microcontrollers with on-chip debugging for source level symbolic debugging, Nano Trace (if supported by the device) and device programming.

2. Overview

The Atmel AVR Real Color ZLL LED Light Bulb kit is intended to demonstrate the Atmel AVR Atmega256RFR2 single-chip microcontroller and radio transceiver which is used in the Bulb application via ZigBee Light Link protocol. The kit includes three circuit boards: Power Supply Board, MCU Control Board, and LED String Board.

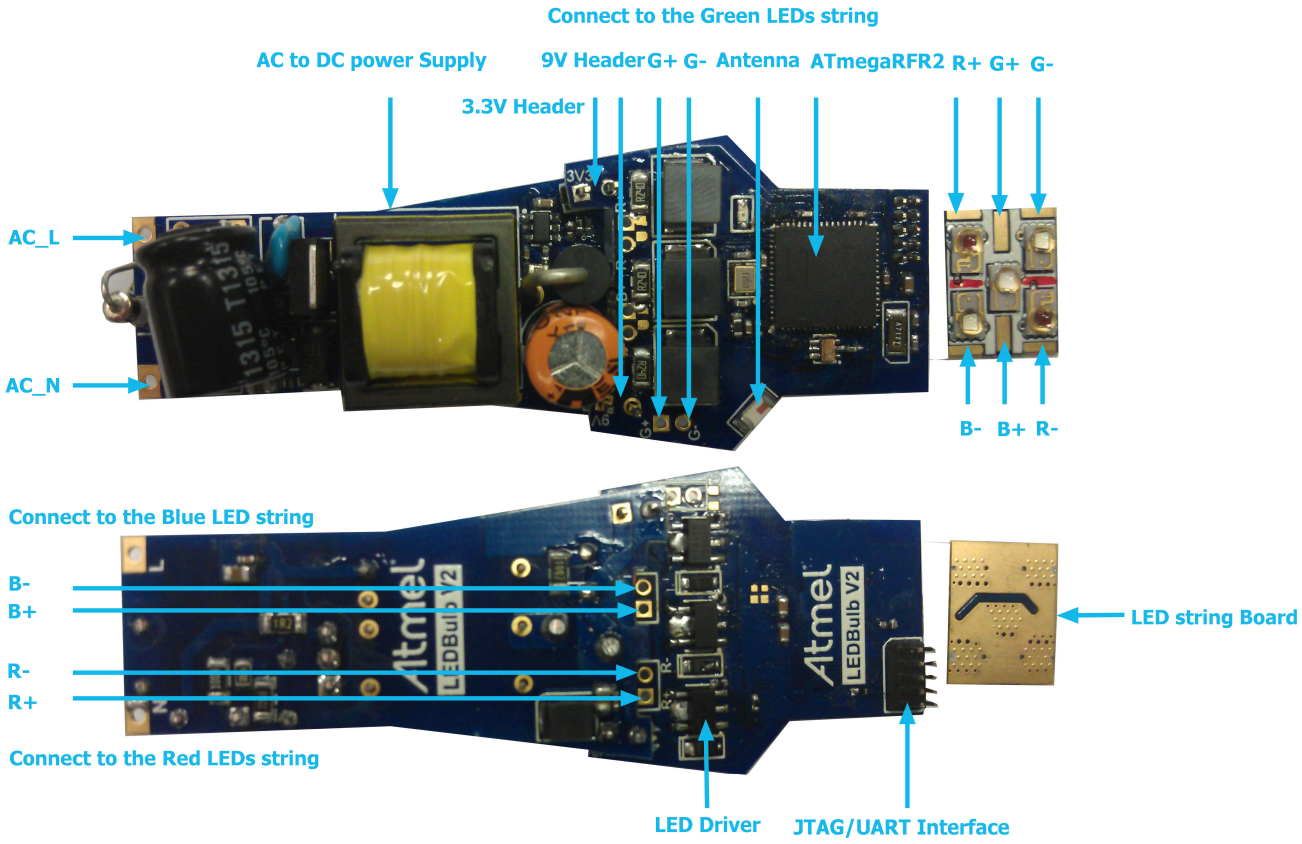
Power Supply Board contains the AC to DC switching power supply and the DC to DC circuit. It supplies power for the whole system. The board provides 9.3V and up to 850mA.

MCU Control Board contains the MCU ATmega256RFR2, antenna, and the LED driver controller.

LED String Board is configured as three parallel LED strings: two Green LEDs, two Red LEDs and one Blue LED.

Figure 2-1 shows the available features on the board.

Figure 2-1. Overview of Real Color ZLL LED Light Bulb



2.2 Components for Setup

The components listed in Table 2-1 are necessary to perform all functions of the reference design.

Table 2-1. Components for Kit Setup

Component	Function
Lamp with E27 Reference hardware Kit	ZLL Bulb assembled with Power Supply Board, MCU Control Board, and LED String Board
Lamp Holder with E27	Supply 110V/220VAC and 50/60Hz frequency Power to the kit
Programming Tool with JTAG interface	Debug and Programming
ZLL/Ethernet Gateway	Communicate between the kit and Wi-Fi Router
Wi-Fi Router	Communicate between the Tablet or Smartphone and ZLL/Ethernet Gateway
Tablet or Smartphone based on the Android System	Control the kit using application software
Application Software	Running on the Tablet or Smartphone to control the Kit

2.1 Preprogramming Firmware

The Atmel ATmega256RFR2 on the kit is programmed with the default firmware. The detailed description of the firmware is available in the AT06482 Real Color ZLL LED Light Bulb with ATmega256RFR2 – Software User Guide.

2.2 Power Supply

The kit is powered from an AC line in the voltage range 85VAC and 264VA with 50/60Hz frequency. The AC to DC switching power supply can deliver 9.3V and up to 850mA.

The 9.3V is converted to proper voltage and supply to LED string. It is also regulated down to 3.3V by an onboard DC-DC regulator, which provides power to the entire main board.

2.3 Programming the Kit

The kit can be programmed from an external programming tool through the JTAG interface.

3. Connectors

The Real Color ZLL LED Light Bulb kit has several connectors and headers dedicated for difference purposes. They are shown in Table 3-1.

Table 3-1. Connector and Functions

Connector	Function
J1	Green LED String connector
J2	Blue LED String connector
J3	Red LED String connector
J4	AC source connector
J5	JTAG/UART interface for programming and debug
J6,J8	9VDC power header
J7,J9	3.3VDC power header

3.1 LED Strings Connector

The J1, J2, J3 are the LED Strings connector. It provides a connection from the MCU Control Board to the LED String Board. The header is polarity sensitive.

Table 3-2. Green LED String Connector J1

Pin on Green LED String Connector	Name on the LED Connector
1	G+
2	G-

Table 3-3. Blue LED String Connector J2

Pin on Blue LED String Connector	Name on the LED Connector
1	B+
2	B-

Table 3-4. Red LED String Connector J3

Pin on Blue LED String Connector	Name on the LED Connector
1	R+
2	R-

3.2 AC Source Connector

The AC Source Connector J4 connects to AC line which is a high voltage.

> Pay attention; DO NOT touch them for your safety when running the kit.

Table 3-5. AC Source Connector J4

Pin on AC Source Connector	Name on the AC Source Connector
1	L (LIVE WIRE)
2	N (NEUTRAL WIRE)

3.3 JTAG/UART Header

The Atmel AVR ATmega256RFR2 can be programmed and debugged via JTAG header. Any tools which carry the JTAG interface can program and debug the kit. JTAGICE3 is recommended for programming. The definition of the JTAG interface can be found in Table 3-6.

Table 3-6. AVR ATmega256RFR2 Programming and Debugging Interface -JTAG

Pin on programming header	Pin on AVR ATmega256RFR2	JTAG
1	PF4	TCK
2	-	GND
3	PF6	TDO
4	-	VCC
5	PF5	TMS
6	RSTN	nSRST
7	-	-
8	-	-
9	PF7	TDI
10	-	GND

The definition of the UART interface can be found in Table 3-7.

Table 3-7. AVR ATmega256RFR2 Universal Asynchronous Receiver/Transmitter Interface - UART

Pin on programming header	Pin on AVR ATmega256RFR2	UART
1	-	-
2	-	GND
3	-	-
4	-	VCC
5	-	-
6	-	-
7	PE0	RXD
8	PE1	TXD
9	-	-
10	-	-

The JTAG and UART interface uses the different pins at the same header.

3.4 9VDC Power Header

The connectors J6 and J8 provide a connection of the 9VDC from the Power Supply Board to the MCU Control Board. The header is polarity sensitive.

Table 3-8. 9VDC Power Header

Pin on 9VDC power header	Name on the 9VDC power header
1	9V+
2	GND

3.5 3.3VDC Power Header

The connectors J7 and J9 provide a connection of the 3.3VDC from the Power Supply Board to the MCU Control Board. The header is polarity sensitive.

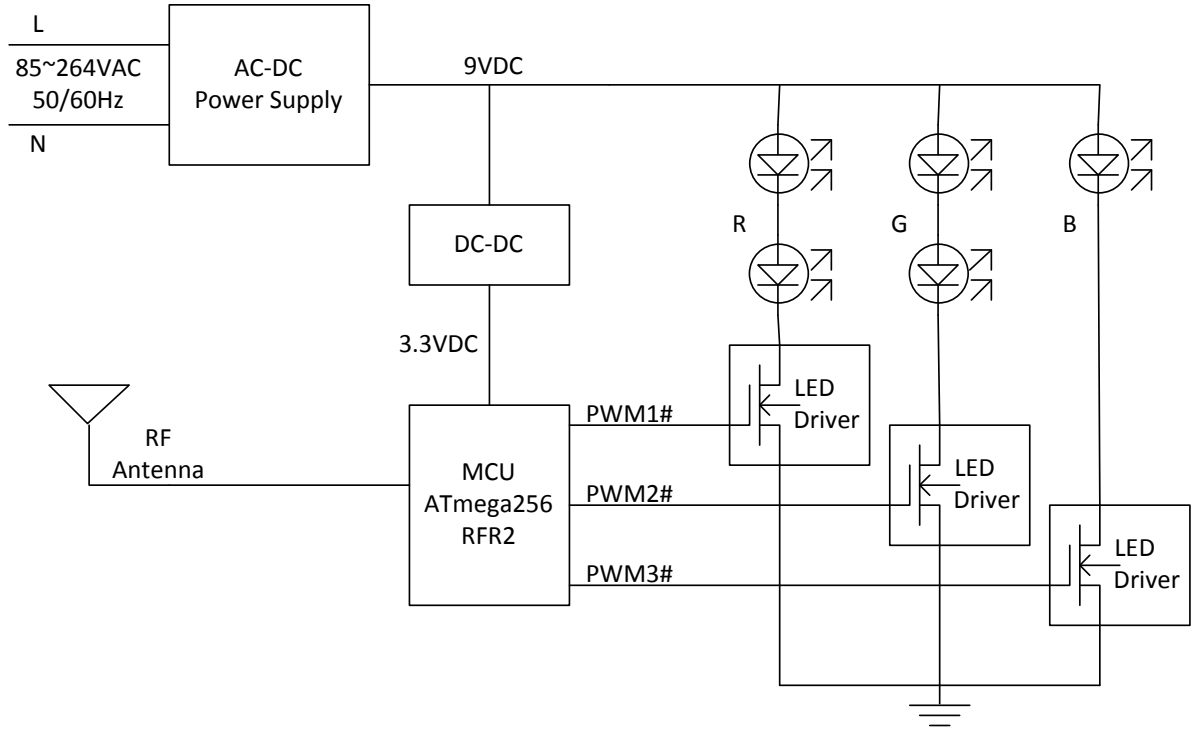
Table 3-9. 3.3VDC Power Header

Pin on 3.3VDC power header	Name on the 3.3VDC power header
1	3.3V+
2	GND

4. Peripherals

Figure 4-1 shows the Real Color ZLL LED Light Bulb system block diagram.

Figure 4-1. Real Color ZLL LED Light Bulb System Block Diagram



Warning: The kit has high voltages on the board that pose a shock hazard to the user. Appropriate care should be taken when operating the board. In addition to the high power LEDs are used on the LED String board. Do not look directly at the LEDs when the board is active and/or protect your eyes with dark glasses since the LEDs are very bright.

To turn on the board, simply plug the power cord into an 85V to 264V and 50/60Hz frequency power source. The LEDs light at application of power.

4.1 AC to DC Switching Power Supply

The AC to DC switching power supply, the iw1706, is used to PWM controller. The power supply uses a primary-side control technology to eliminate the opto-isolated feedback and secondary regulation circuits required in traditional designs.

The AC to DC power supply works at the fixed-frequency Discontinuous Conduction Mode (DCM) operation at higher output load, and switches to variable frequency operation at light output load for obtaining maximum efficiency. In other words, it uses adaptive multi-mode PWM/PFM control to dynamically change the BJT switching frequency for efficiency and EMI.

The AC to DC power supply build-in fault protection features include overvoltage protection (OVP), output short circuit protection (SCP), and over current protection (OCP).

The AC to DC power supply provides 9.3V and up to 850mA for system, and input voltage range is 85V to 264VAC with 50/60Hz frequency.

4.2 LED Driver

The PT4115 device is used as LED driver. It is a continuous conduction mode inductive step-down converter, designed for driving single or multiple series connected LED from a voltage source. The device operates from an input power supply between 8V to 30V, and provides an externally adjustable output current of up to 1.2A via set by the sample resistance Rs. The device includes the power switch, and accepts either a DC voltage or a PWM dimming. In this reference design, the PWM dimming method is used. In order to avoid the flicker of the LED, the PWM frequency set to 1kHz in the design.

Note: It is better that the voltage difference between the input supply and the LED string more than 2V.

Figure 4-2 shows the typical application circuit of the PT4115.

Figure 4-2. Typical Application Circuit of the PT4115

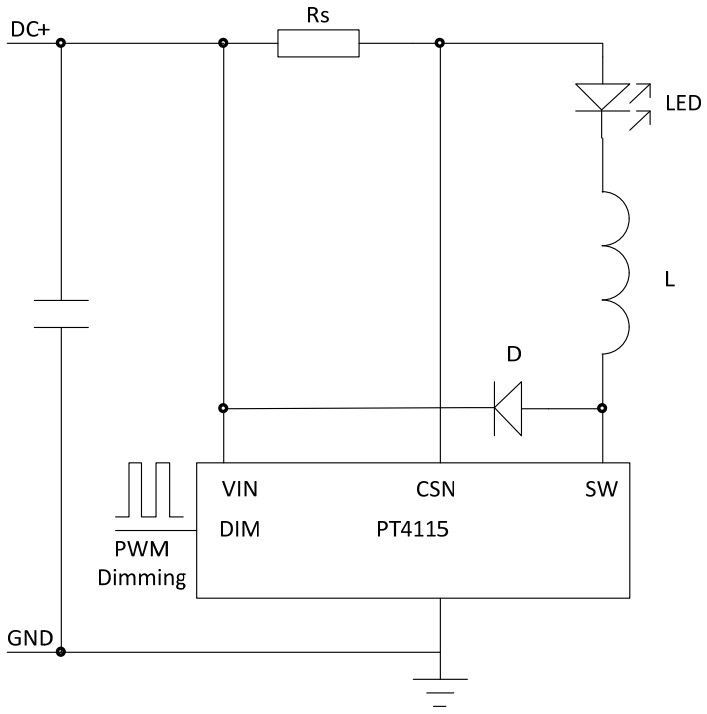


Table 4-1. PWM Dimming of the LED Strings

Pin on AVR ATmega256RFR2	Function
PE3	Dimming Red String LED
PE4	Dimming Blue String LED
PE5	Dimming Green String LED

4.2.1 Diode Selection

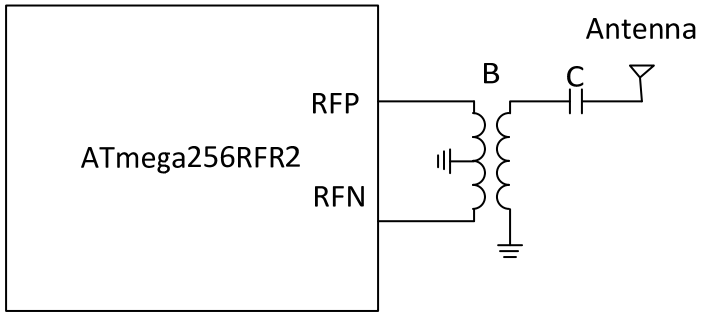
For maximum efficiency and performance, the rectifier D should be a fast low capacitance Schottky diode with low reverse leakage at the maximum operating voltage and temperature. It is important to select parts with a peak current rating above the peak coil current and a continuous current rating higher than the maximum output load current. It is very important to consider the reverse leakage of the diode when operating above 85°C. Excess leakage will increase the power dissipation in the device and if close to the load may create a thermal runaway condition.

4.3 ZigBee Transceiver

The Atmel AVR ATmega256RFR2 device integrated a high performance RF-CMOS 2.4GHz radio transceiver.

In the design, only four components, ATmega256RFR2, Balun, Capacitance and Antenna, consist of RF function circuit.

Figure 4-3. RF Function Circuit



In order to obtain high performance about the RF, the PCB layout is very important.

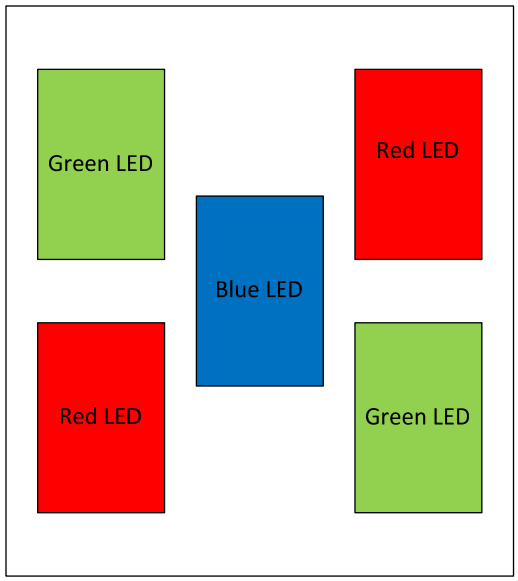
How to design the PCB about the RF circuit; refer to the application note Atmel AVR10004: RCB256RFR2 – Hardware User Manual.

4.4 LED String Board

> Pay attention; DO NOT look at the LEDs directly when they are lit. Otherwise LEDs may potentially harm the user's eyes.

In order to get the perfect feeling of mixed color, two Green LEDs, two Red LEDs and one Blue LED are used in the design, and the LEDs should be well positioned in PCB layout.

Figure 4-4. Placement of the LEDs



4.5 LED Indicator

There is a LED available on the board that can be used to indicate the working condition of the kit. The green LED can be activated by driving the connected I/O line to VCC.

Table 4-2. LED Connections

Pin on AVR ATmega256RFR2	LED
PE2	Green LED

4.6 Temperature Sensor

The design is equipped with one temperature sensor (100kΩ NTC) connected to the ADC channel of the MCU. The power is supplied by 3.3VDC. The ADC reference is internal 1.6V reference voltage to reduce the error caused by external power.

Table 4-3. Temperature Sensor Connection

Pin on AVR ATmega256RFR2	Temperature Sensor
PF1	NTC

5. Code Examples

The example application is based on the Atmel Software Framework that is included in Atmel Studio 6. The Atmel Software Framework can also be found as a separate package online at:

http://www.atmel.com/tools/avrsoftwareframework.aspx.

For more information about the code example, see the application note AT06482: Real Color ZLL LED Light Bulb Reference Design with ATmega256RFR2 – Software User's Guide.

Revision History

Doc. Rev.	Date	Comments
42241A	02/2014	Initial document revision

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