TDA4863, ICE2HS01G, BCR450

120W LED Street Light Power Supply

Application Note

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Revision History	
Page or Item	**Subjects (major changes since previous revision)**
Revision 1.0, 08.06.2011	

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1 Introduction

This application note describes a reference design of 120W LED Street Light Power Supply.
Table below shows the line up of this power supply in different output voltage and communication interface.

Output voltage & Power / Communication Interface	36V - 42V (120W)	46V - 52V (140W)
DALI	Available	Available
without DALI	Available	Available

1.1 Features

- 2-stage power supply topology with feedback control
- Supply voltage: 90 – 264 VAC
- Output voltage/ Power: 36 V to 42 VDC (120W version)
  46 V to 52 VDC (140W version)
- Output current: 4 channels x 680 mA
- Power factor > 0.95
- PWM dimming from 25% ~ 100%
- Overall power efficiency above 91%
- Open- and short-circuit protection and auto-detection
- Soft-start voltage programmable from 30 V
- Start-up speed control
- Brownout function
- Over-temperature protection
- Upgradeable microcontroller for software protocol implementation, e.g. DALI

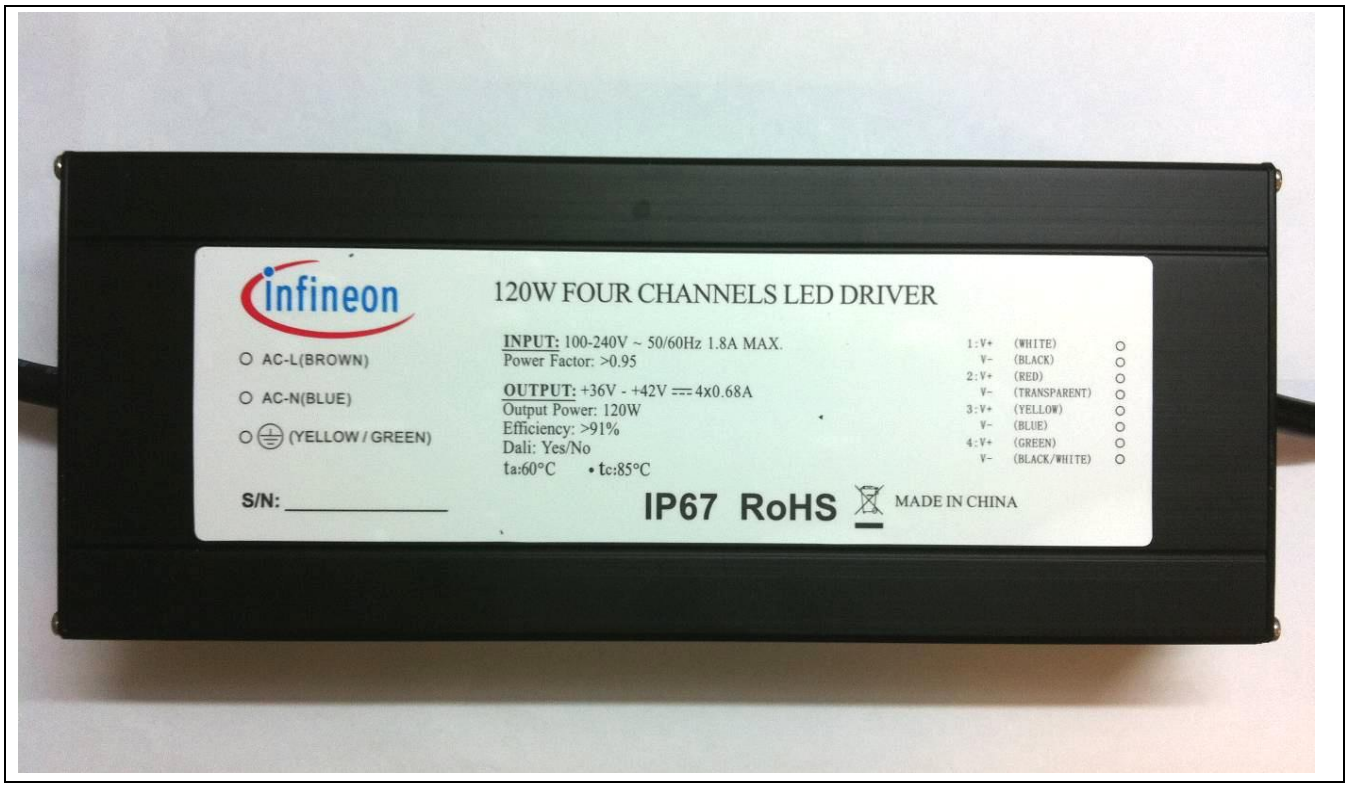


Figure 1 120W LED Street Light Power Supply

1.2 Key Advantages

- No electromagnetic interference (EMI) on secondary side with linear LED driver
- No electrolytic capacitor on secondary side to ensure long lifetime of the street lighting
- Fewer external components on secondary side to increase reliability and reduce costs
- Very high DC-DC power efficiency, up to 98% with linear LED driver
- Wide LED input voltage range, makes it easy for user to adjust LED number in a string
- Flexible number of modules combination, 1 – 8 channels
- Flexible LED current configuration, up to 2A per channel LED current
- Easy to reprogram when parameters change
- Phase-shift dimming, reduced impact on the power grid
- Communication interface

1.3 System Overview

The design includes the TDA4863-2G for power-factor correction, using a boost-converter topology. This Power-Factor Controller PFC drives a high-voltage MOSFET to achieve a 400-VDC output voltage.

The ICE2HS01G is a high-performance pulse-frequency-modulated resonant controller, especially half-bridge LLC resonant converter. It operates at a 50% duty cycle for two primary gate drives and is 180 degrees out of phase. This works together with pulse transistor, driver IC, and primary- and secondary-side MOSFET to step down the DC voltage to between 36 V and 42 V before these current drive a 4-channel LED light source.

In parallel, the ICE3BR4765J is an off-line low-cost flyback switch-mode power supply (SMPS) with an integrated 650 V CoolMOS that provide 5-V and 12-V internal voltage supplies to the IC.

A linear LED driver, BCR450, is used with an external power transistor, BDP947, to provide approximately 700 mA. This output current can be adjusted with an external sense resistor. A Pulse-Width Modulation (PWM) input to the linear driver allows for dimming operation to regulate LED brightness.

The microcontroller provides the on, off and dimming control to the linear driver along with open- and short-circuit protection on all 4 LED channels. It monitors the voltage drop on the 4 LED channels and generates a feedback signal to the LLC converter to maximize efficiency. There are 2 plug-in cards supported: XC824 for preset dimming level, and XC835 for programmable dimming levels and lighting control using standard Digital Addressable Lighting Interface (DALI) commands via a DALI bus.

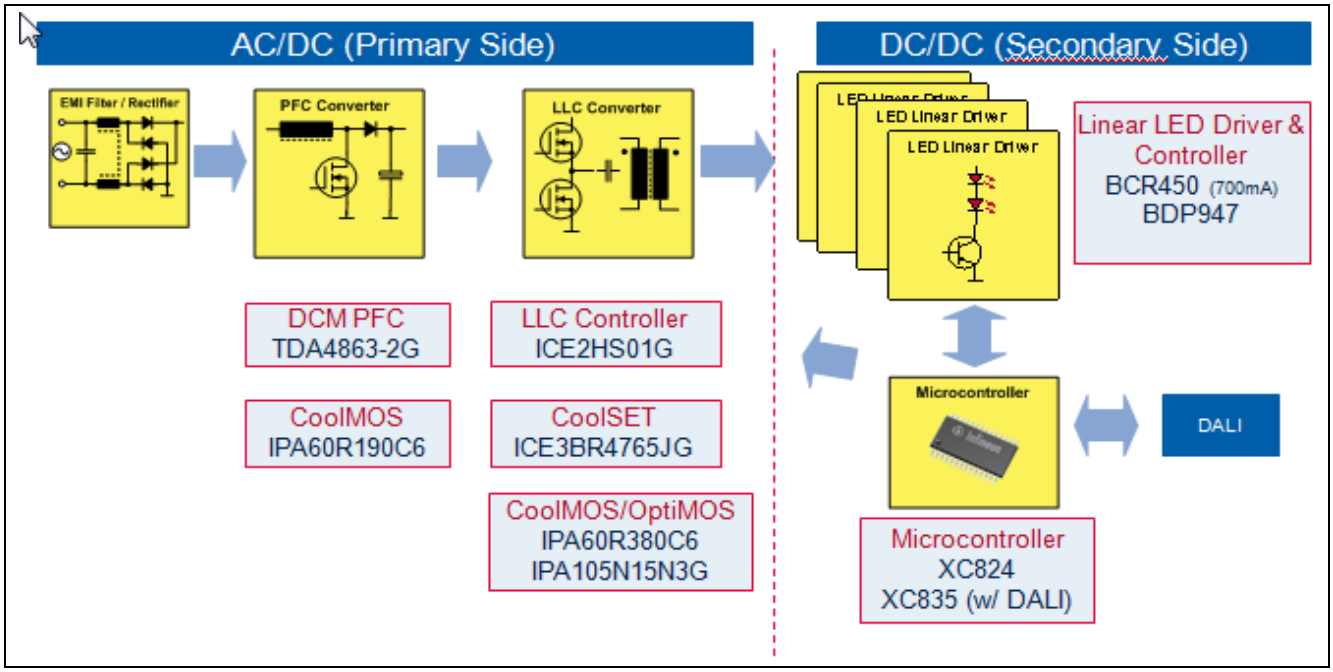


Figure 2 Key Components for Each Function

2 Technical Specification

Parameter		Value
Max. Output Power (4 channels)		120 W / 140W
Single Channel Parameter	Output Current	0.68 A per channel
	Current Accuracy	+/- 3%
	Output Voltage Range	36 V - 42 V (120W max) 46 V – 52 V (140W max)
	Startup Time	1000 ms @ 230 V AC; 3000 ms @ 115 V AC
Input	Voltage Range	90 V AC – 264 V AC
	Frequency	47 Hz – 63 Hz
	Power Factor	PF > 0.95 @ 230 V AC; PF > 0.98 @ 115 V AC
	Efficiency	> 91% @ 230 V AC
	Surge Current	20 A @ 115 V AC; 40 A @ 230 V AC
	Leakage Current	< 1 mA @ 240 V AC
Protection	Short-circuit Protection	Condition: Output short circuit
		Method: Independent single-channel protection with auto recovery
	Over-voltage Protection	Condition: > 55 V DC
		Method: Limit the maximum voltage
	Over-temperature Protection	Condition: 105 +/-5 degrees C (detect the internal heat sink temperature)
		Method: Turn off output, auto recovery
Environment	Operation Temperature, Humidity	-20 to +50 degrees C; 20% to 90 % Relative Humidity (RH) without cooling system
	Storage Temperature, Humidity	-40 to +85 degrees C; 10% to 95% RH
Safety and Electromagnetic Compatibility	Hipot / Withstand Voltage	I/P - O/P: 3 KV AC
	Surge Immunity	EN61000-4-5 (Level 3), Performance Criteria B
	Electromagnetic Interference	EN55015, GB9254 CLASSB
	Harmonic Current	IEC61000-3-2 CLASS C

3 Circuit Description

This switching-mode power supply for LED street-lighting systems has three major parts:

- The microcontroller is the central control unit for the system.
- The LED driver circuit uses BCR450 as the controller and has four channels to drive the LED lamps; the LED driver circuit takes power from the AC/DC converter and provides constant current to each channel of the LED lamps.
- The AC/DC converter provides DC power to the LED driver circuits with an constant but adjustable output voltage. This is used to optimize the efficiency of the total system. In addition, the AC/DC converter also provides the power supply to the microcontroller circuit.

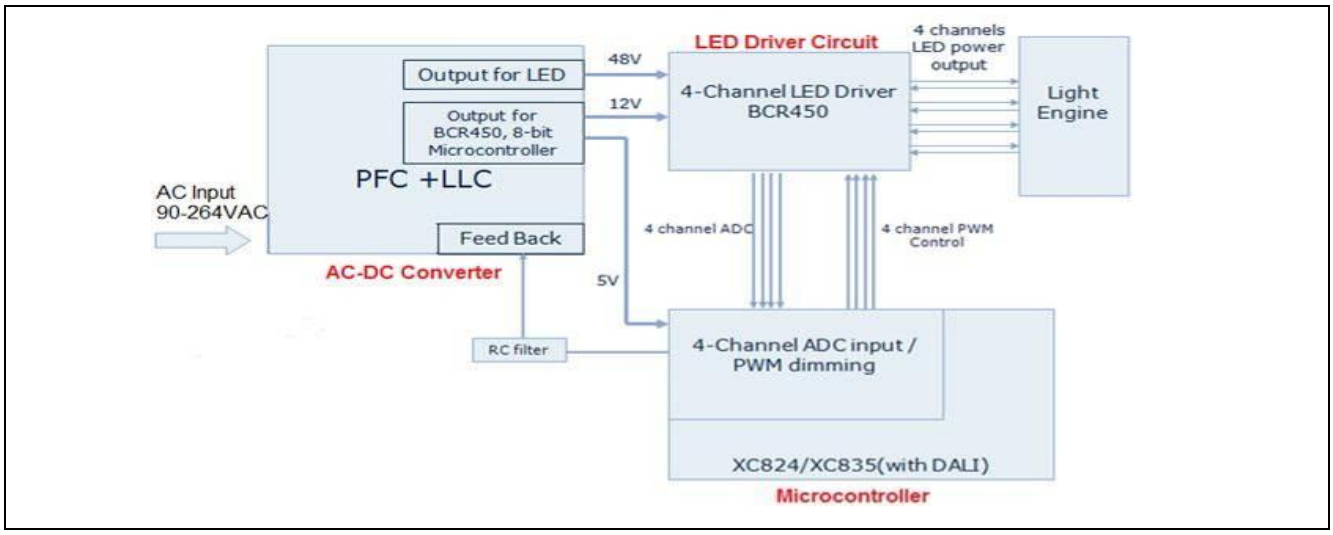


Figure 3 System Block Diagram

The AC/DC converter has three major stages as well:

- The front-end PFC preregulator takes the AC power from the main line and converts it into DC power with a constant 400 VDC bus.
- The main power stage, an LLC resonant half-bridge converter, converts the 400 V DC bus voltage into 36 - 42 V DC to optimize the driver efficiency. In addition, the LLC resonant half-bridge converter provides the safety isolation between the mains and the LED driver circuit.
- The standby converter provides power to all the controllers such as PFC control, LLC half-bridge control, and microcontroller at the secondary stage.

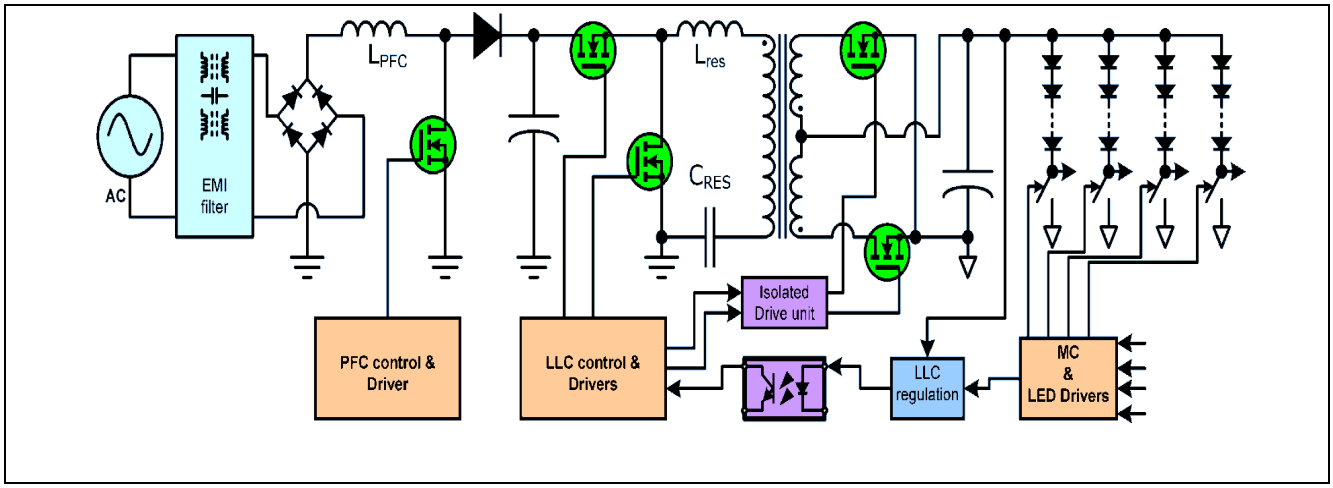


Figure 4 Detail System block diagram

3.1 Mains Input and Rectification

The AC line input comprises the input fuse F1 as overcurrent protection. The Chokes LF1 and LF2, X2-Capacitors CX1 and CX2 are used as radio interference suppressors.

RV1 is the surge protector and RX1 through RX4 are used to discharge X2 Capacitors after AC voltage is removed.

In addition, there is a π filter after the bridge rectifier, BR1. The filter consists of C5, C6 and L2. This circuit filters out high-frequency current ripple generated by the PFC boost converter.

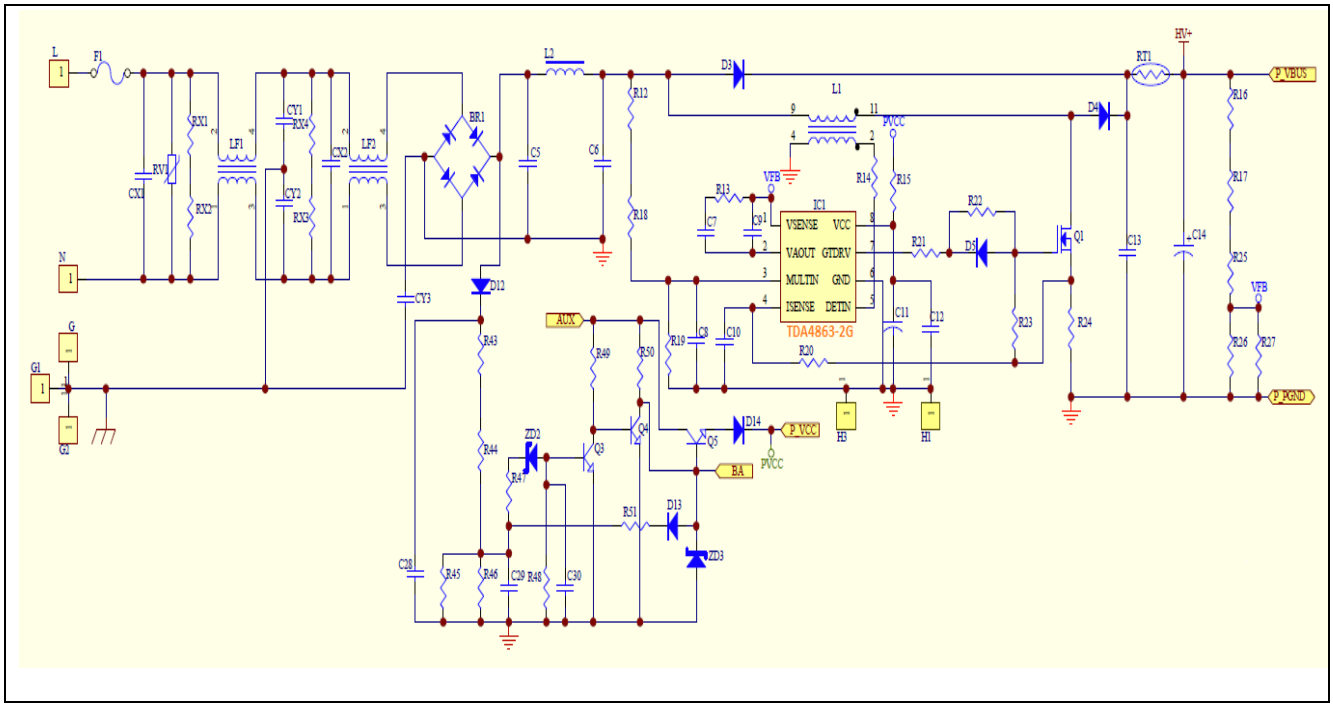


Figure 5 Schematic of Mains Input, Rectification & PFC Circuit

3.2 Power Factor Correction Converter: TDA4863-2G

After the bridge rectifier, it is a boost-type PFC converter consisting of L1, Q1, D4, and C13 and C14. The CoolMOS® CP IPA60R199CP is used as the power switch Q1. Due to its low RDSon and small output capacitance, a small heat sink can fulfill the dissipation requirement. Output capacitor C14 provides energy buffering to reduce the output voltage ripple. In addition, the RT1 in series in the power loop is used to limit the current flow into the converter during AC power on.

The MOSFET Q1 current is sensed by the external shunt resistor R24. The sense voltage is fed into IC1, TDA4863-2G Pin 4 and compared to the internal control voltage for PWM control. In addition, a compensation circuit of R23, R20 and C10 is added to improve power limitation of the pre-converter.

The PWM control is accomplished by the 8-pin Boundary Mode PFC controller IC TDA4863-2G. The output voltage is sensed by the voltage divider of R16, R17, R25, R26, and R27.

The compensation network C7, C9 and R13 constitutes the external circuitry of the error amplifier. This circuitry allows the feedback to be matched to various load conditions, thereby providing stable control. In order to avoid 100 Hz ripple, the loop compensation is implemented with low bandwidth, normally within 20 Hz. The output voltage of the error amplifier is sent to the internal multiplier and multiplied with a sine-wave-sensing signal. The sine-wave-sensing signal is obtained through the resistive divider connected to the output voltage of the bridge rectifier. R12, R18, and R19 form the resistive divider. Capacitor C8 is added to MULT pin to filter out the possible coupled noise. The multiplier output is used as an internal control voltage for peak current mode PEM control. The gate is turned off when the peak-current-sensing signal exceeds the control voltage.

The zero-current detector senses the inductor current via an auxiliary winding of the main inductor L1. It ensures that the next on-time of the MOSFET is initiated immediately when the inductor current has reached zero. This reduces the reverse recovery losses of the boost-converter diode, D4, to a minimum. In addition, the MOSFET Q1 is turned on at a low drain-source voltage for minimum turn-on loss. Inside the DETIN pin, there are both

positive and negative voltage-clamping circuits. To limit the current flowing into DETIN pin during MOSFET off period, the resistor R14 is inserted between the auxiliary winding and the IC pin.

The IC TDA4863-2G positive power supply is provided by the auxiliary converter. To maintain a regulated voltage against the load change of the auxiliary converter, a linear regulator consisting of Q5, ZD3 and D14 is used. In addition, the circuit consisting of D12, R43 to R50, ZD2, Q2, and Q3 is an external protection circuit. This circuit will pull down the IC Vcc power supplies when the input line voltage is too low. In addition, hysteresis is added with R51 and D13, so that the system enters into a brown-out condition with a lower AC voltage and leaves the brown-out condition with a higher input AC voltage.

The IC output gate driver is a fast totem pole gate drive specially designed for large MOSFETs. The gate-drive resistor R21 in series with R22 is used to limit the turn-on speed of Q1, while the diode D5 is used to provide a fast turn-off of Q1.

3.3 LLC Resonant Half-Bridge Converter: ICE2HS01G

The LLC resonant half-bridge converter is chosen as the main converter due to its simple operation scheme, high conversion efficiency, and simple design. To further increase the conversion efficiency, synchronous rectification MOSFETs are used at the secondary side instead of rectifier diodes.

The main power stage converts the 400 V bus voltage into a lower output voltage in the range of 36-42 V.

The power stage of this LLC resonant half-bridge converter includes Q108 and Q111; both are CoolMOS™ E6 series, **IPA60R190E6**, as the primary switches. T102 is the main transformer with a core size of PQ3230, L101 is the resonant inductor in the RM8 core, and C122 is the resonant capacitor. Q109 and Q112 are the synchronous rectifier MOSFETs; both are new OptiMOS **IPA105N15N3G** parts.

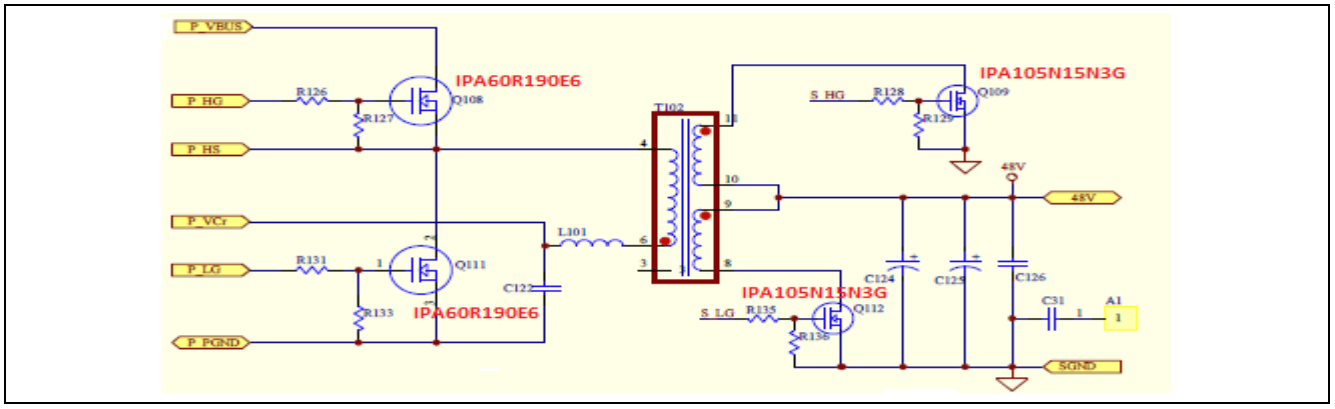


Figure 6 Schematic of LLC Main DC-DC Circuit

For the PFM control, the output voltage of main converter is sensed by resistor divider R151, R152, and R150. The IC104, together with C136, R149, C132, C131, and R148, forms a compensation network of the LLC output voltage control. R140, R141, and R143 in series with IC103 provide a voltage-to-current transfer to primary side.

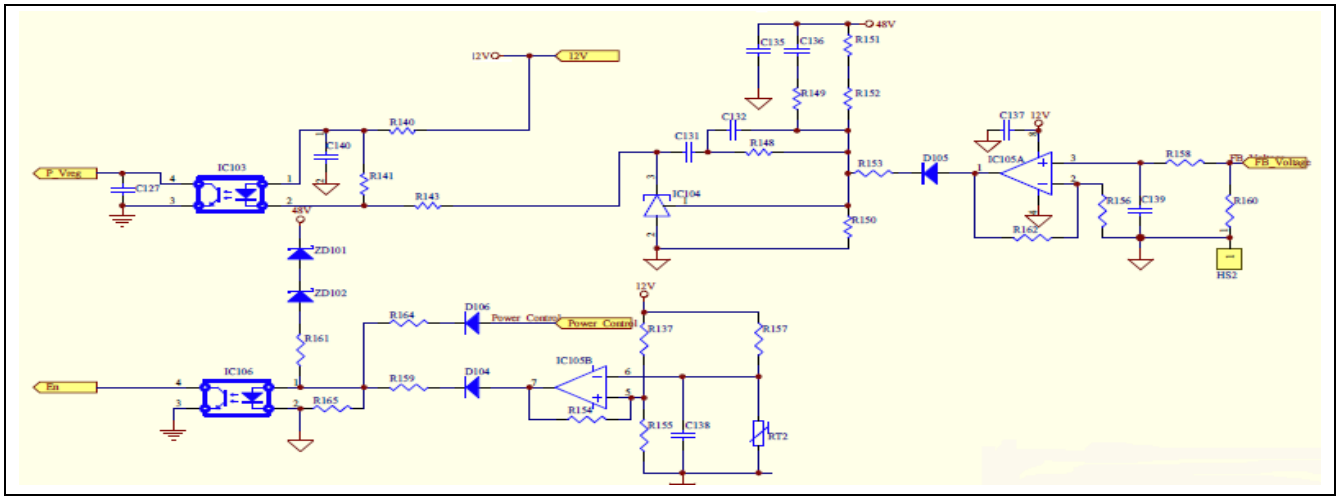


Figure 7 Schematic of LLC Output Control & Feedback Circuit

To improve the drive efficiency for multi-channel LEDs, it is necessary to adjust the output voltage of the main power stage to an optimized level. Op-amp IC105A will take the output from the microcontroller and provides a minor adjustment to the output voltage divider. As shown in the circuit, if the output voltage of IC105A is higher, the output voltage of the main converter is lower.

The circuit consisting of IC105B, R137, R155, R154, D104, R161, R157, and R159 is designed to control output power

Both the primary MOSFET and secondary MOSFET are controlled by the single controller, ICE2HS01G, a newly developed product that is targeted at high efficiency LLC resonant half-bridge converters with secondary synchronous rectification.

ICE2HS01G provide the Pulse-Frequency Modulation (PFM) control. R246 sets the minimum operation frequency of the converter. R245, between the collector of the opto-coupler IC103 and FREQ pin of the IC203, serves as the feedback resistor. R245 and R246, in parallel, determine the maximum operation frequency for load regulation of the converter.

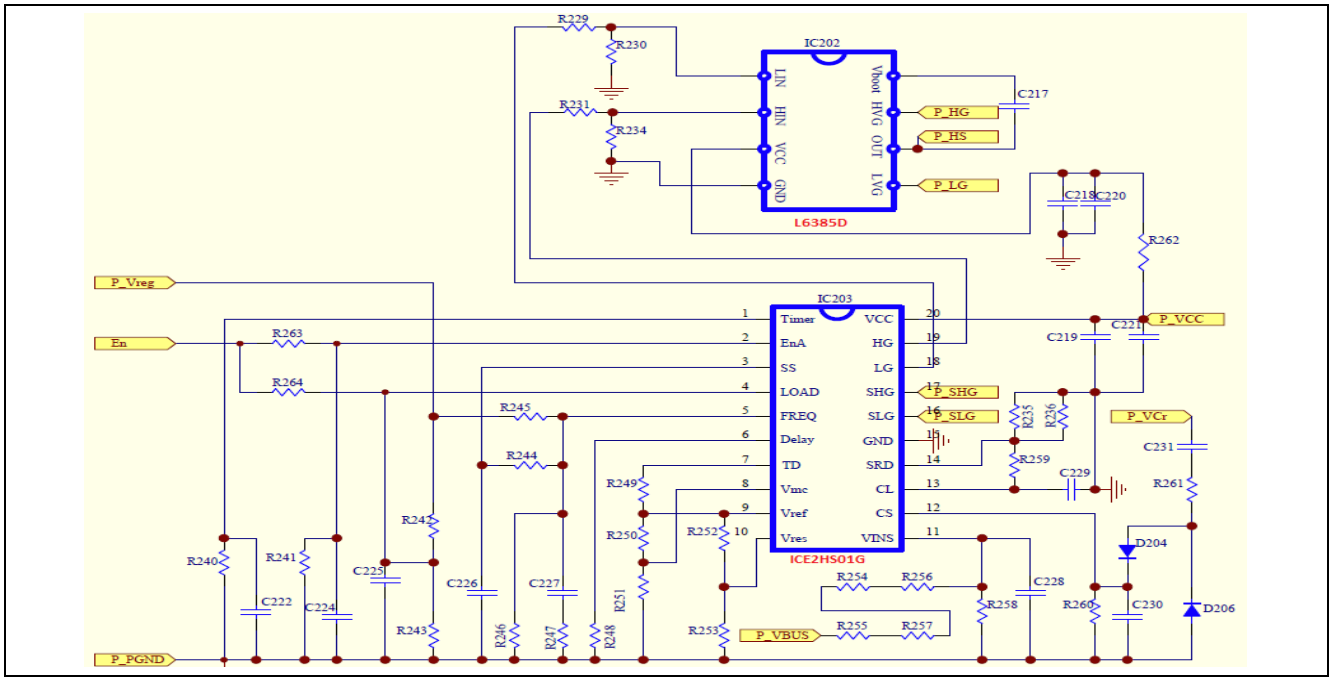


Figure 8 Schematic of LLC Primary Control Circuit

With resistor R245 as the feedback resistor, ICE2HS01G will vary the switching frequency based on sensed current flowing from the FREQ pin. The more current flowing out, the higher the switching frequency will be. To provide a transition between the high/low side switches for zero-voltage switching, a dead time needs to be inserted, and it is set by the resistor R249 connected between Pin 9 and Pin 7 of ICE2HS01G.

In addition, R244 and C226 set the soft-start period and soft-start frequency of the main converter. At the same time, R244 in parallel with R246 determine the maximum operation frequency during short-circuit or over-current output conditions.

ICE2HS01G offers an innovative synchronous rectification control for LLC resonant half-bridge converters. It provides 2 logic signals for the primary MOSFET control, and 2 logic signals for the secondary MOSFET control. Basically, the two primary MOSFETs are turned on/off with a constant 50% duty cycle and the switching frequency is determined by the feedback signal. The two secondary MOSFETs are turned on/off depending on the primary switches where the duty cycles of secondary MOSFETs are a maximum of 50% and can be reduced depending on load conditions. The duty cycle of secondary MOSFETs is set by choosing suitable values of R235, R236, R259, C229 and the current-sense circuit including C231, R261, D204, D206, C230, and R260.

At the primary side, if high voltage isolation is required, HV IC IC202 is used to drive the two primary MOSFETs.

As the delay from primary to secondary is usually longer than the delay from low-side IC to high-side IC, a delay time is set by R248. This delay is the minimum time that two SR logic signals (SHG, SLG) are turned on before the two primary gate signals (HG, LG) are turned off.

The current-sense circuit including C231, R261, D204, D206, C230, and R260 protects the system. Once the voltage on the CS pin is higher than 0.8 V, ICE2HS01G will increase the switching frequency to limit the resonant current in the power stage.

ICE2HS01G also provides overload protection. The blanking time and restart time for overload protection are set by R240 and C222 connected to the Timer pin.

C224, connected to the EnA pin, is used to select whether ICE2HS01G will enter burst mode during a light load condition. If an NTC resistor is used for R241, external over-temperature protection can be set.

Resistor divider R254 to R258, and C228 provide bus under-voltage protection for the main power stage.

As the IC is located at the primary side power supply, the logic drive signals for the secondary MOSFET are transferred using the pulse transformer. Q113 to Q116 and R130, R132, R138, R139, and C128, T103, D102, R134, R144, D103, R142, R145, ZD103, and ZD104 are the driver circuit. To improve the converter efficiency, MOSFET driver IC IC102 is used to drive the secondary MOSFET.

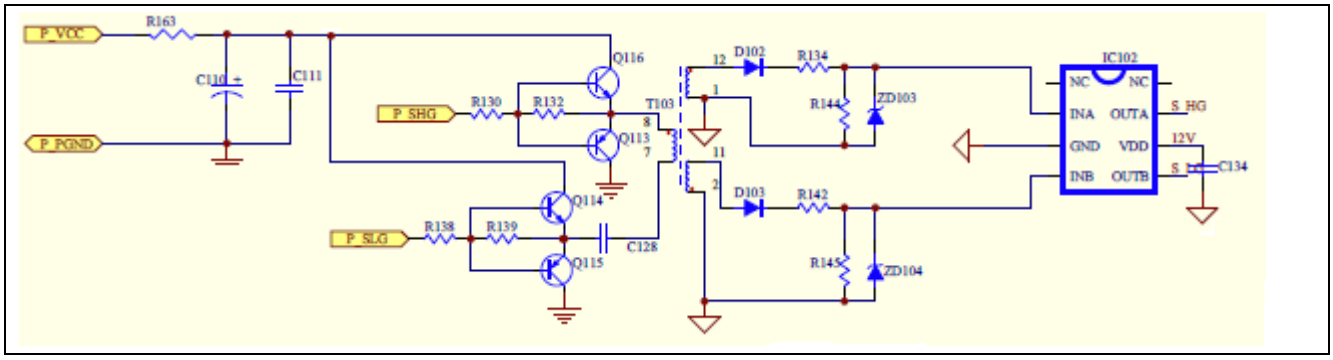


Figure 9 Schematic of LLC Secondary Control Circuit

3.4 Auxiliary Flyback Converter: ICE3BR4765J

The auxiliary flyback converter is implemented with integrated power IC CoolSET® F3R ICE3BR4765J, a fixed frequency current mode PWM controller with integrated MOSFET.

The auxiliary flyback converter consists of transformer T1, IC2 ICE3BR4765J, and an output stage including D9 and D10 as the output rectifier, and C21, C22, and C23 as the output buffering. The output of the converter is 12 V at 0.5 A and 5 V at 0.2 A. The feedback loop includes the TL431 (U2) and optocoupler PC617A-3 (IC4).

To maintain good output regulation, only 12 V is well-regulated. A regulator LM7805 is used to keep the 5 V ouput stable.

This auxiliary flyback converter is designed to operate over the whole mains voltage range, even when the PFC stage is not working. The auxiliary winding of transformer T1 supplies the power to ICE3BR4765J during operation. It is also intended to supply the other controllers including TDA4863-2G, ICE2HS01G, and HVDriver IC.

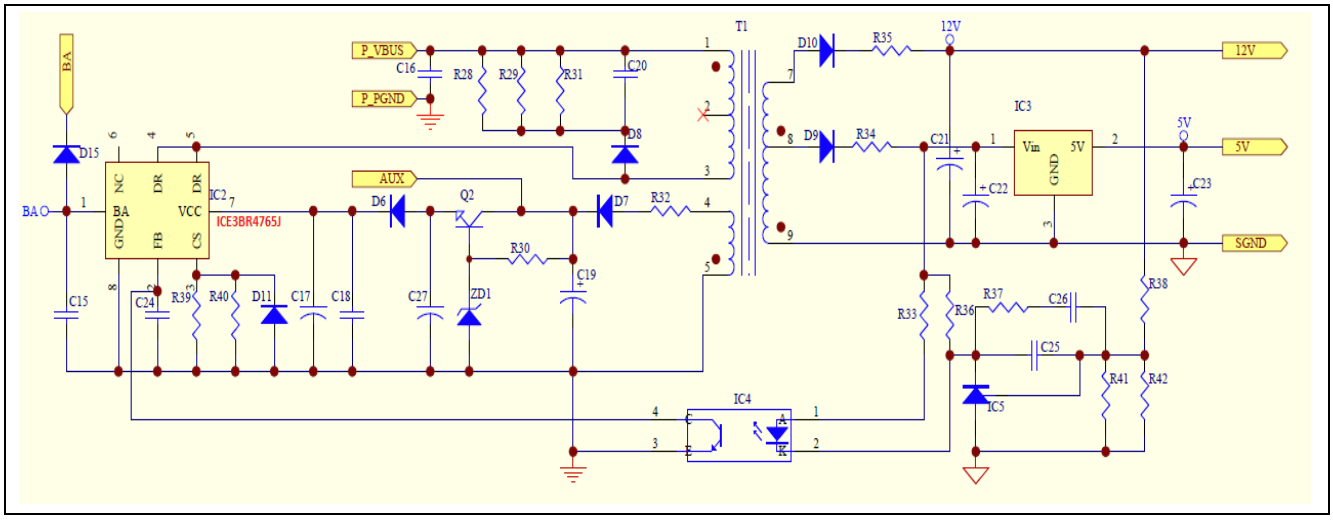


Figure 10 Schematic of Auxiliary Power Supply

3.5 LED Driver: BCR450

The BCR450, with features such as high output-current accuracy of +/- 1.5%, overcurrent and overvoltage protection, and the ability to protect the LEDs from thermal overstress, is designed for high-current general lighting applications.

The 85 mA current in standalone mode can be extended to up to 2.0 A with an external booster transistor.

3.5.1 Features of the BCR450

- High output current precision of +/- 1.5% at 25°C
- Current range:
  - Standalone mode: up to 85 mA
  - Booster circuit: 85 mA – 2000 mA
- Maximum operating voltage: 27 V
- Overvoltage and overcurrent protection
- Thermal shutdown
- Low voltage overhead in boost mode of only 0.5 V
  - (0.15 V at sense resistor + 0.35 V at booster transistor)
- Direct PWM possible due to logic level enable input
- Small 6-pin SC74 package

3.5.2 Benefits of the BCR450

- Thermal shutdown protects the LEDs from permanent damage
- Linear concept eliminates EMI problems
- External power stage allows improved heat dissipation by comparison to monolithic drivers
- Higher count of LEDs possible in a string due to very low voltage overhead
- Less space needed on PCB, as no coils or inductors are required and no external digital transistor for PWM
- Excellent price-performance ratio, due to separation of power stage from higher-cost IC technology
- Appropriate for rchitectural lighting
- Excellent for for light bars and strobe lights for emergency vehicles
- Ideal for infrared security cameras and infrared spot lights
- Good for illumination for machine vision
- Safer for EMI-sensitive applications such as aircraft cabin lighting and medical lighting
- Versatile choice for high-power general lighting applications

3.5.3 BCR450 Block Diagram and Pin Configuration

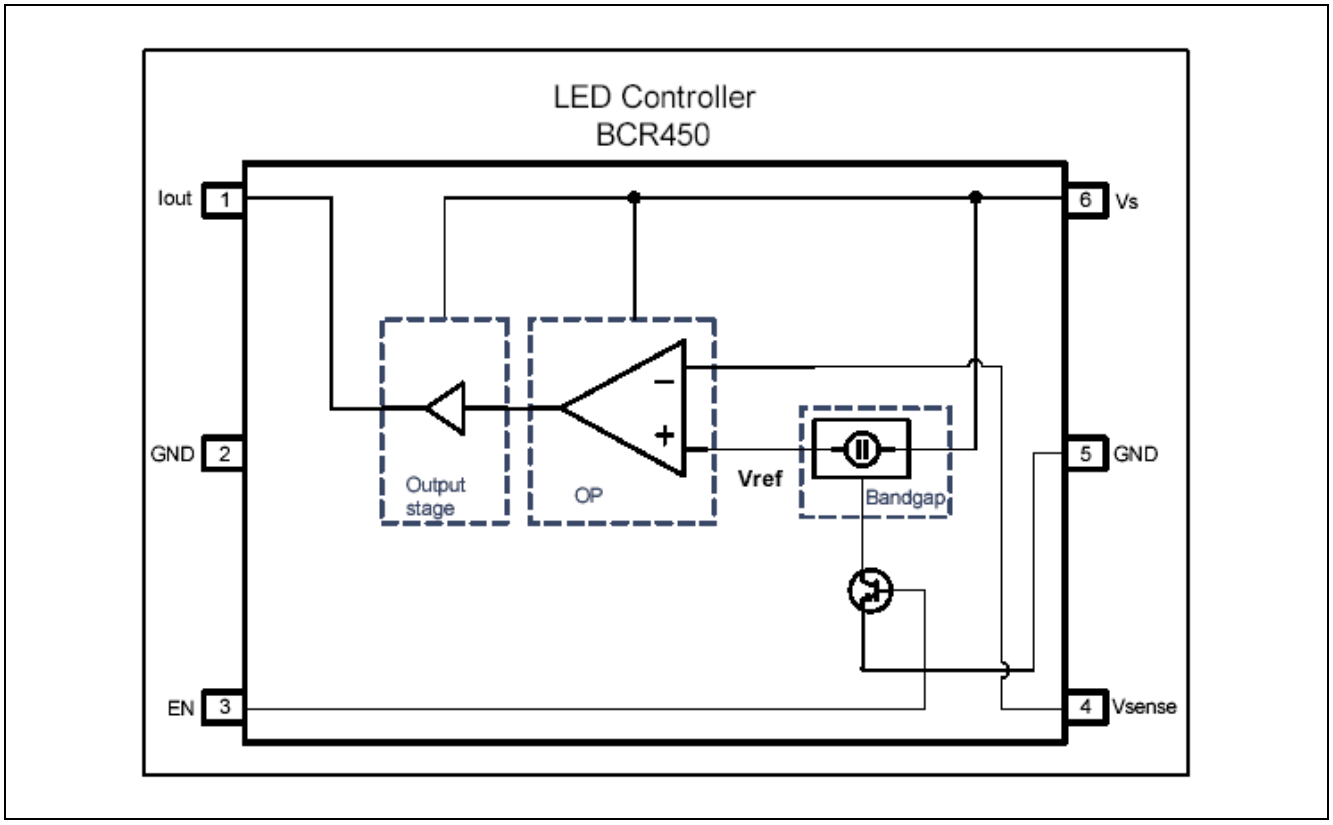


Figure 11 BCR450 Internal Block Diagram

3.5.4 The Booster Concept

To extend the current range of the BCR450 to current levels beyond 85 mA, another approach is needed. To reach the 700 mA current required for such higher power LED applications, ***the LED driver is used as a "controller" and an external "booster transistor" is employed to handle the higher current and heat dissipation.***

To choose an approriate transistor, the power dissipation and maximum ratings of the devices must be checked and verified for each individual circuit design. As a general guideline, the **BC817SU** is recommended for 0.5-Watt LEDs with currents up to 150 mA; the **BCX68-25** is recommended for 1-W LEDs with currents up to 350 mA; and the **BDP947** is recommended for higher power requirements, mostly 3-W LEDs with current levels between 350 mA and 700 mA as used in this application.

In general, the upper limit on output current for this circuit is only limited by the maximum power dissipation and junction temperature of the boost transistor.

3.5.5 BCR450 Control

There are 4 individual modules in the current reference design. Figure 12 shows one of the channel configurations.

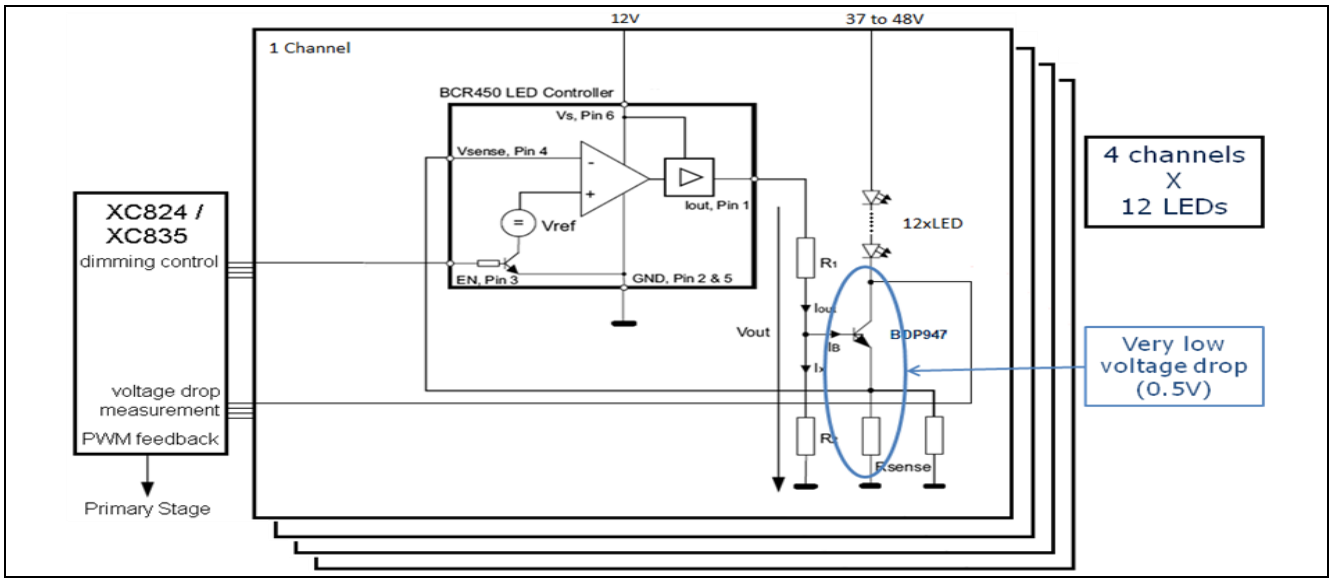


Figure 12 LED Driver Circuit Block Diagram

In order to apply to a different LED numbers and input voltage, we use a 12 V auxiliary power for the BCR450's operating power supply. The main power supply 36 V ~ 42 V is for LED lighting. This concept is employed to avoid having the number of LEDs in each channel limited by the LED driver input voltage. This results in a highly flexible design topology and efficiency.

To reach the highest efficiency, the microcontroller will measure each LED channel's voltage drop and calculate the maximum efficiency LED input voltage, then feedback to primary side to adjust the input DC voltage.

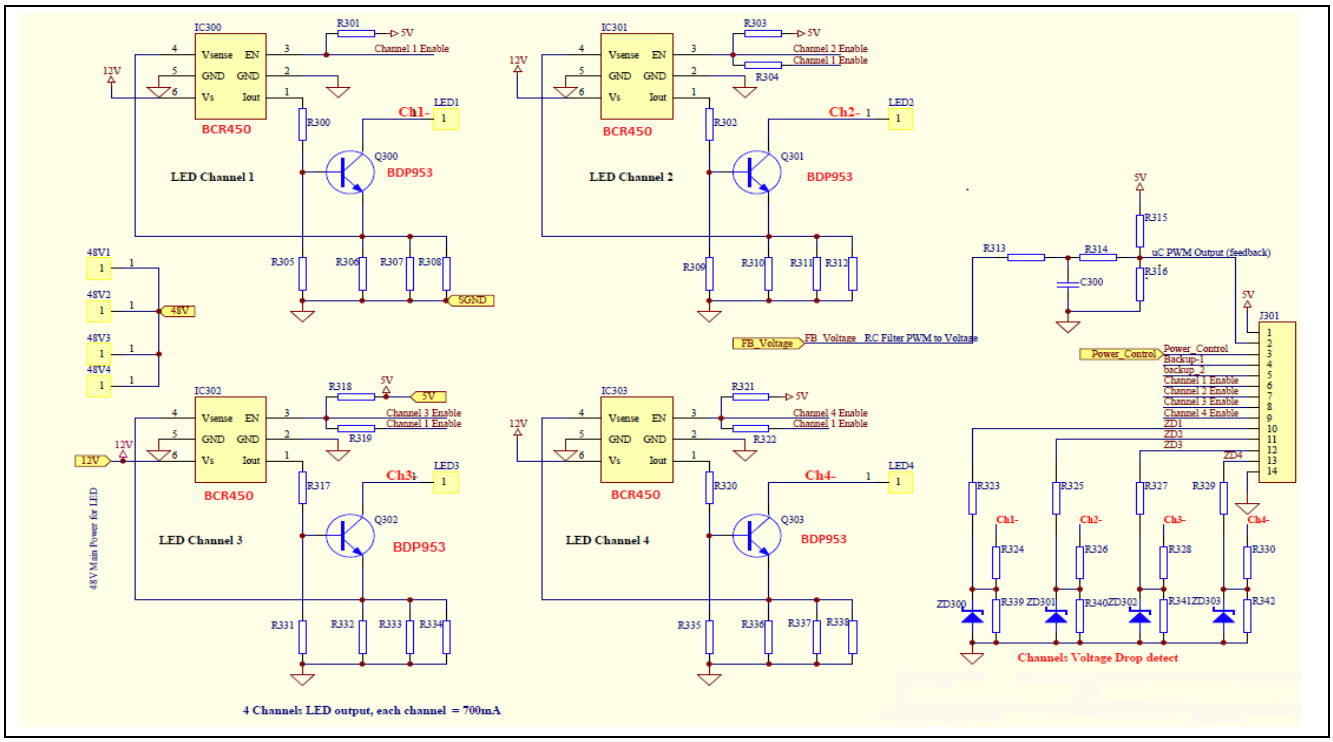


Figure 13 Schematic of LED Driver Circuit

3.6 Microcontroller: XC800

The high-performance XC800 family of 8-bit microcontrollers has the XC800 Core that is compatible with the industry standard 8051 processor. It is equipped with a powerful Capture-and-Compare Unit (*CCU6*) and a 10-bit Analog-to-Digital Converter (*ADC*) with extended functionalities. These features make the XC800 microcontrollers very suitable for low-cost control applications.

The microcontroller is on a separate plug-in board. It controls the 4 LED channels by providing a dimming signal (*Channel_x_Enable*) for each BCR450 driver IC in an interleaved manner. The brightness of the LEDs can be controlled via preset dimming levels (XC824 or XC835) or programmable dimming levels through DALI network (XC835 only).

The frequency of *Channel_x_Enable* is 900 Hz and the time base is Timer 12 in the Capture and Compare Unit 6 (*CCU6*). The microcontroller provides a power feedback signal (*PWM_FB*) to the primary side as well. This is a PWM signal with variable duty cycle based on the lowest voltage drop on the 4 LED strings, as determined by measuring the voltage on the collector of the 4 power transistors (*ZDx*). The desired voltage drop is 0.5V. If the lowest voltage drop is higher (lower) than 0.5 V, then the duty cycle of the feedback signal will slowly decrease (increase) until the target is reached.

ZDx are used to detect open- or short-circuits on the LED channels as well. When open- or short-circuits occur, the respective channel is turned off. The microcontroller will try to recover the channel 3 times in case the turn-off was due to disturbance to the system. If all 3 recovery attempts are unsuccessful, the channel will be turned off permanently until system restart. If all channels are turned off, the primary side is also turned off completely until system restart.

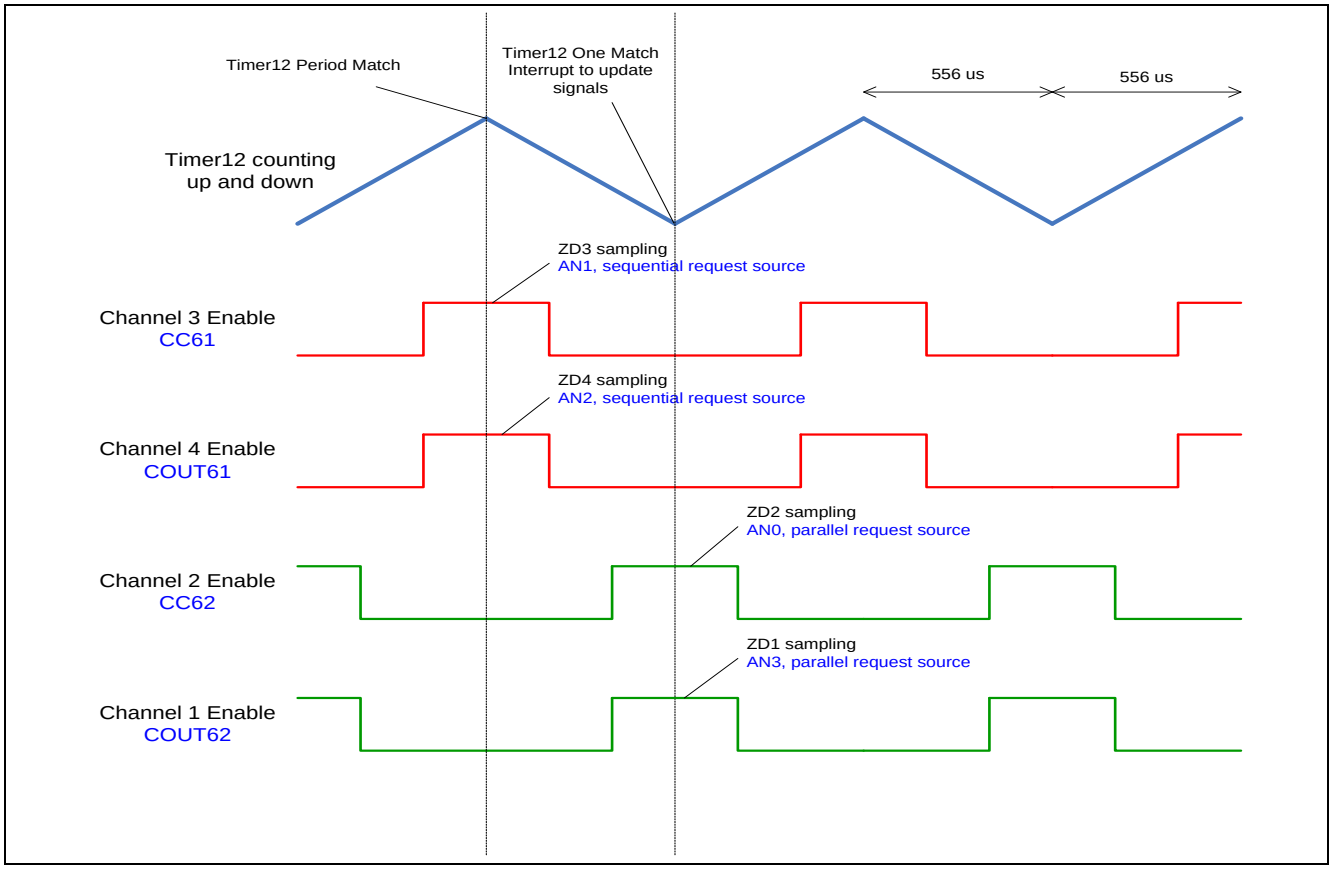


Figure 14 Microcontroller PWM Timing Diagram

ZDx are sampled in the middle of the high time of the respective *Channel_x_Enable*. The *ADC* runs in the background and takes care of sampling and conversion autonomously. The duty cycle of *PWM_FB* is updated based on the *ADC* measurements in the Timer 12 One Match (900 Hz frequency). *Channel_x_Enable* duty cycle updates happen during this interrupt, too.

3.6.1 Preset Dimming Level

The dimming level for the lamps are preset within the program stored in the microcontroller. The current level is configured to 100% brightness level.

This mode can be supported by both XC824 and XC835 plug-in cards.

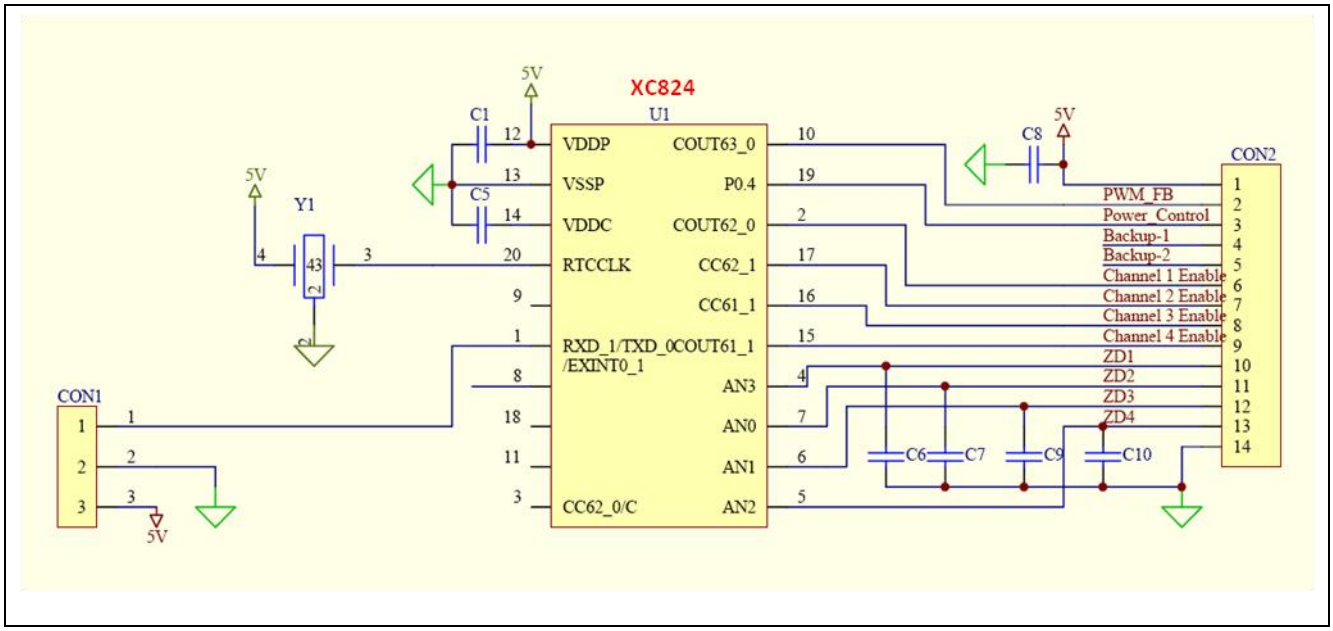


Figure 15 Schematic of XC824 Plug-in Board

3.6.2 Programmable Dimming Level using DALI

The plug-in card allows the user to connect onto a DALI bus for lighting control using standard DALI commands. Users can issue DALI commands to turn ON, OFF and dim the lighting levels. DALI requires only a pair of wires to form the bus for communication to all devices on a single DALI network. Each piece of operating equipment with a DALI interface can be communicated with, over DALI, individually. Using a bidirectional data exchange, a DALI controller can query and set the status of each connected lighting device. As a standalone system, DALI can be operated with a maximum of 64 devices. Alternatively, DALI can be used as a subsystem via DALI gateways for connection to building management systems.

This mode is supported by the XC835 plug-in card only. More information on DALI is available in the application note ”AP08102 DALI Control Gear Software Stack”.

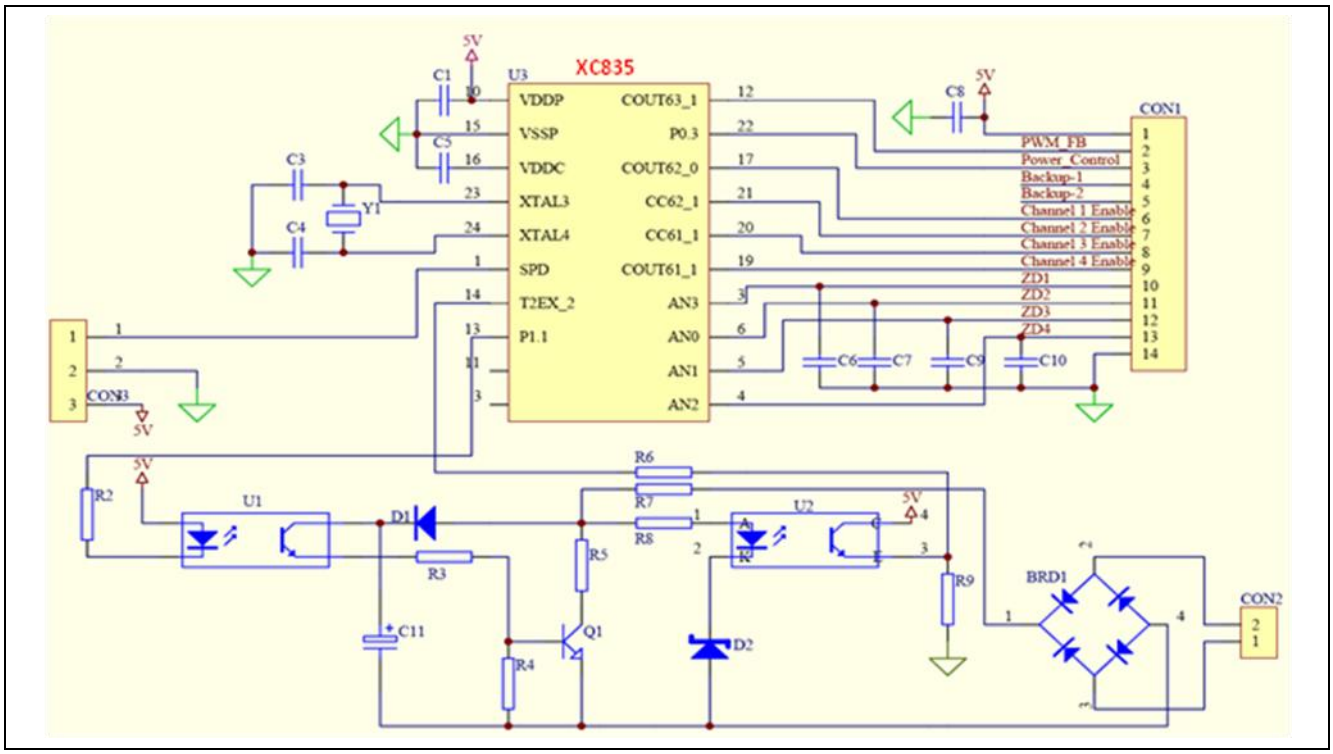


Figure 16 Schematic of XC835 Plug-in Board

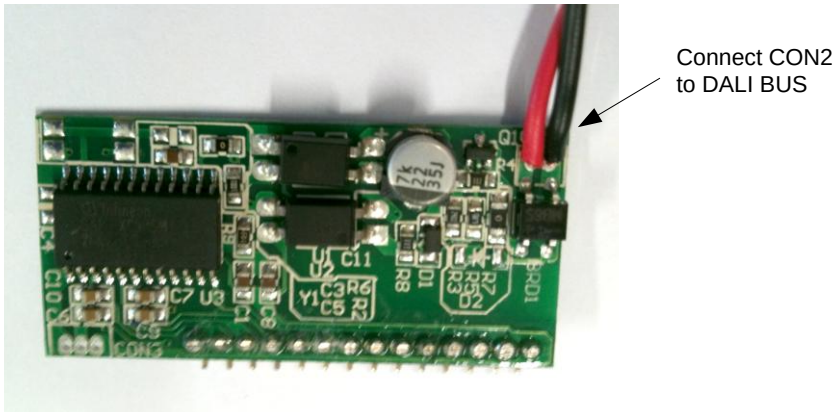


Figure 17 DALI connection on XC835 Plug-in Card

3.6.3 Programming the Microcontroller

Both plug-in boards provide programming access through a 3-pin connector. The software on the microcontroller can be modified and downloaded by the ”DAP miniWiggler” tool (www.infineon.com/miniwiggler) using FLOAD in DAVE BENCH™ or KEIL uVision4. The Boot Mode Index (*BMI*) of the microcontrollers is ”User Mode (Diagnostic)”.

More information is available in the application note ”AP08108 Programming the BMI value in the XC82x and XC83x products”.

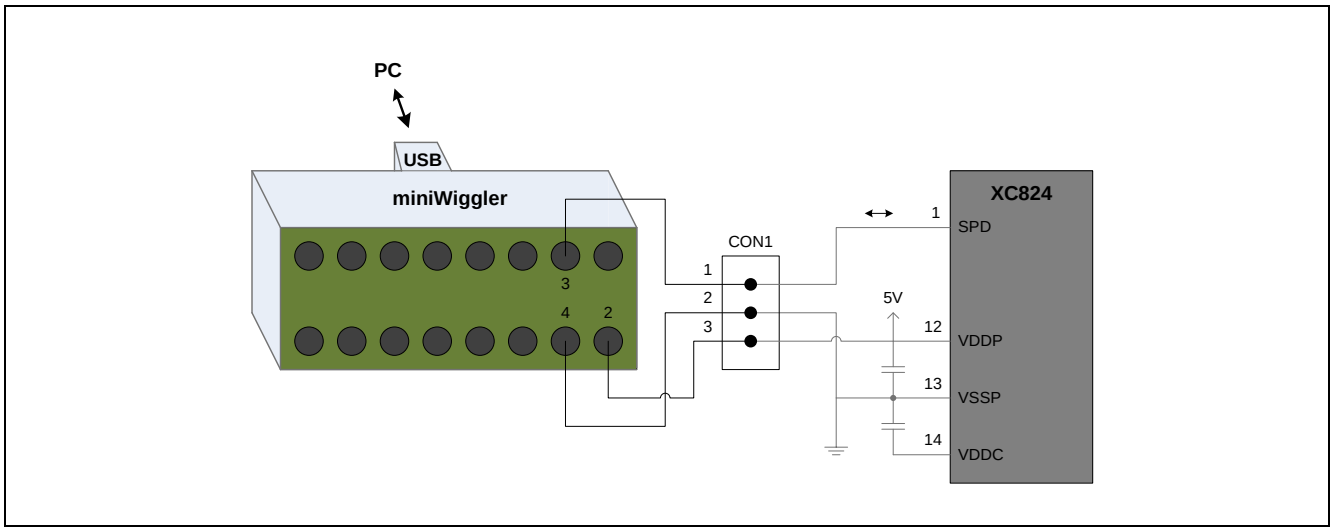


Figure 18 miniWiggler connection to the XC824 Plug-in Board

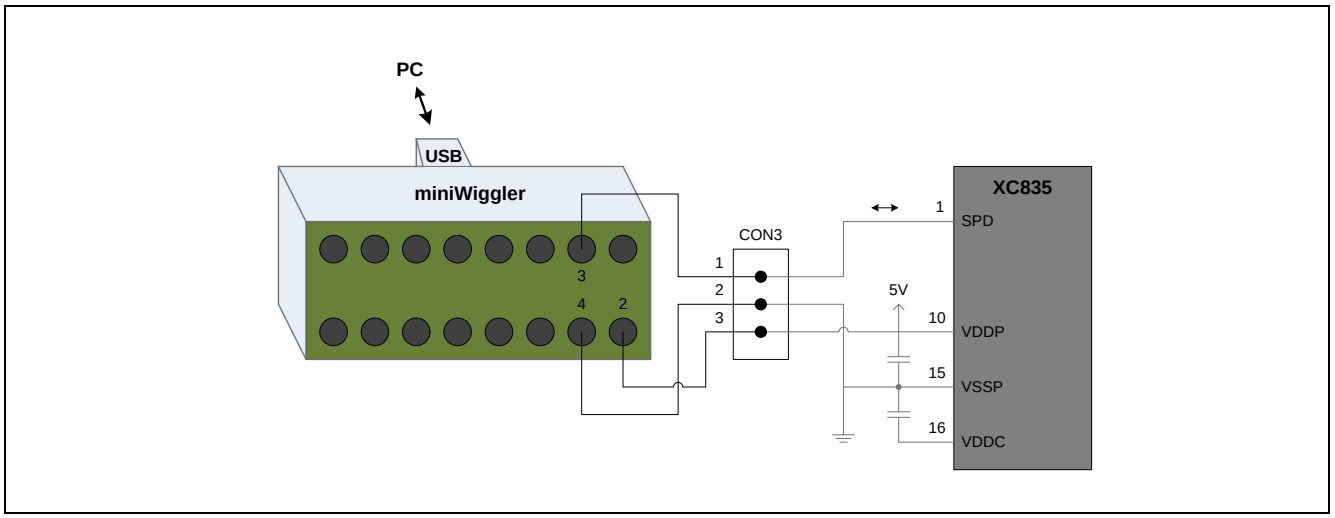


Figure 19 miniWiggler connection to the XC835 Plug-in Board

4 Overview of Power Supply

4.1 Overall Schematic

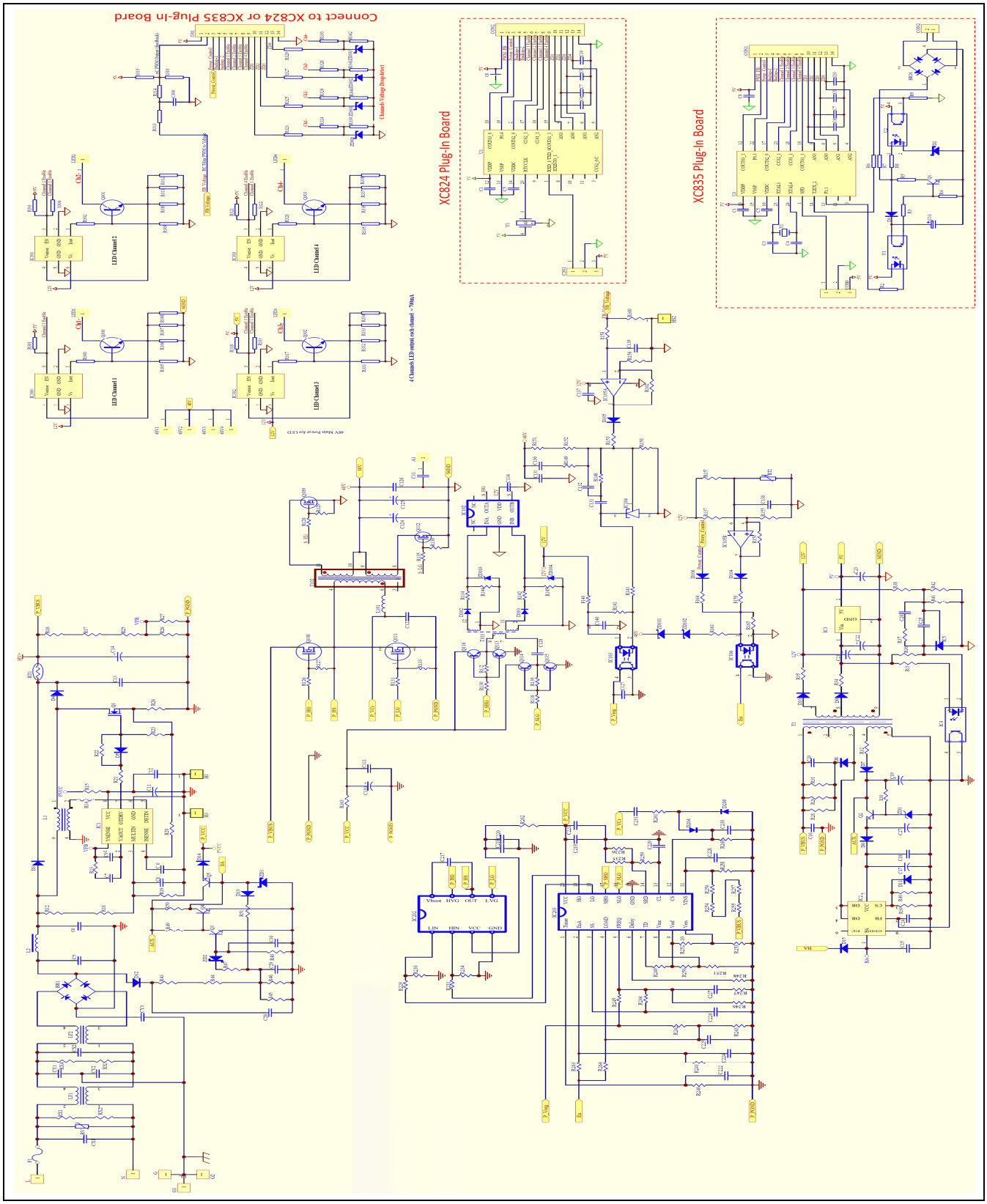


Figure 20 Overall Schematic

4.2 Component Layout

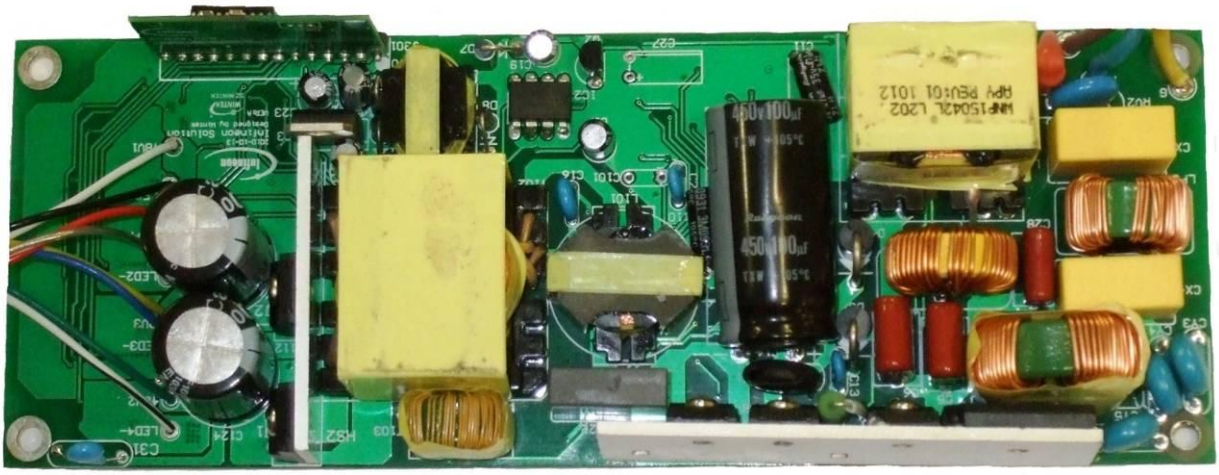
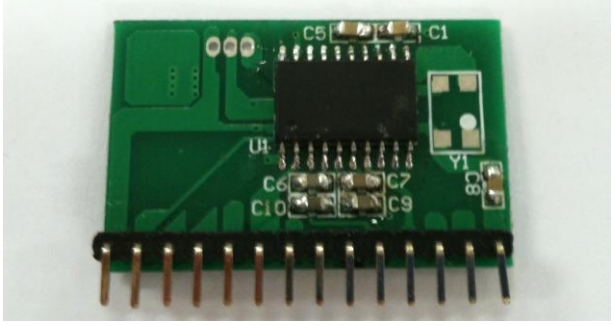


Figure 21 Power Supply Board (Top View)

Figure 22 Power Supply Board (Bottom View)

Plug-In Card XC824



Plug-In Card XC835 (with DALI)

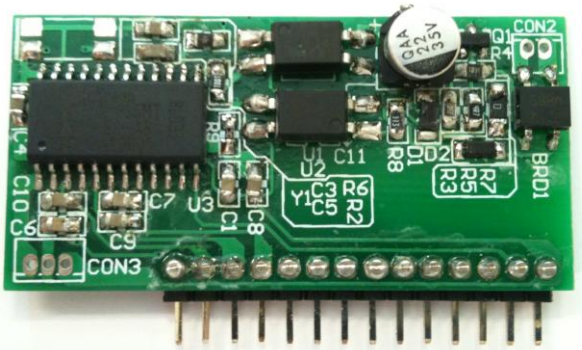


Figure 23 Plug-in Card

4.3 PCB Layout

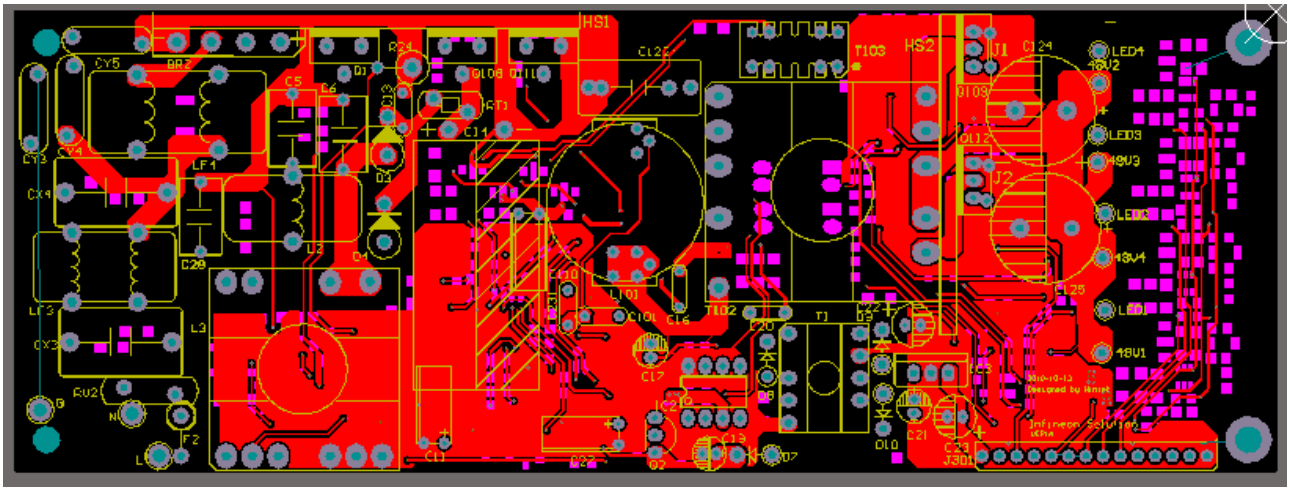


Figure 24 PCB layout top layer view

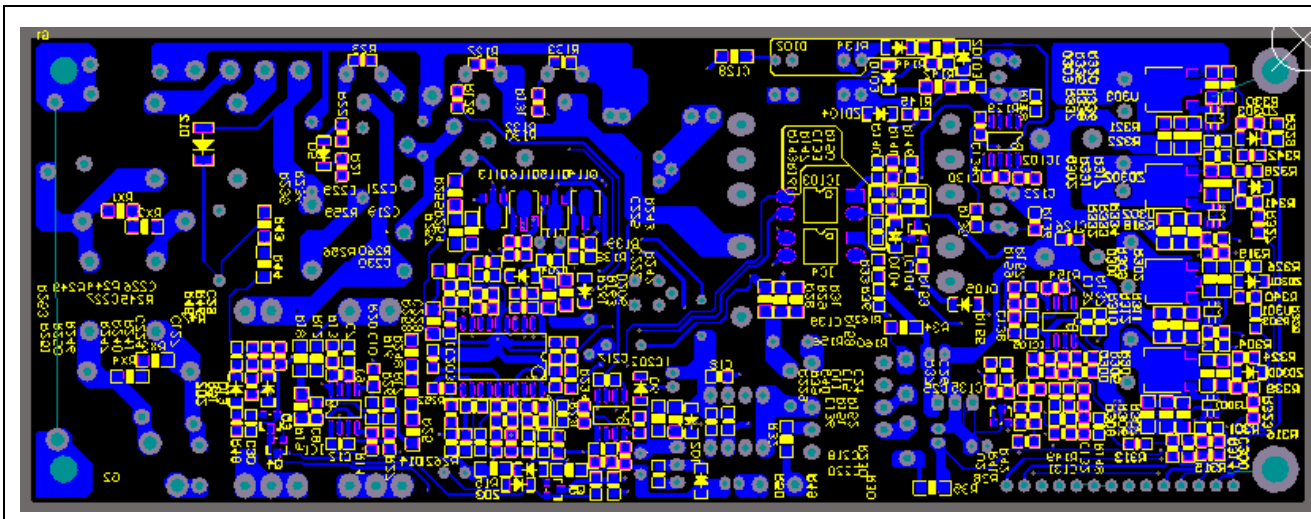


Figure 25 PCB layout bottom layer view

4.4 Bill of Materials

4.4.1 BOM list for Power Supply board

No	Component Description	Qty	Designator	Part Number	Manufacturer
1	Daughter board – WNP12048LM4D_DB1_X824 VER:03-36*22*4-FOR WNP12048LM4D	1	J301		
2	Main Board - WNP12048LM4D VER:03 FR-4,1 Ounce -185*67*1.6mm	1			
3	SMD resistor - 1/8W-0R±5%-0805	1	R247	RS-05K000JT, 0805S8J0000T5E，RTT05000JTP	Royalohm
4	SMD resistor - 1/8W-10K±5%-0805	12	R314, R47,R23, R38, R127,R133,R136, R129,R156, R158, R165, R141	RS-05K103JT, 0805S8J0103T5E，RTT05103JTP	Royalohm
5	SMD resistor - 1/8W-10R±5%-0805	2	R126,R131,	RS-05K100JT,0805S8J0100T5E,RTT05100JTP	Royalohm
6	SMD resistor - 1/8W-1K±5%-0805	8	R36, R315, R323，R325, R327, R329, R251,R140	RS-05K102JT, 0805S8J0102T5E，RTT05102JTP	Royalohm
7	SMD resistor -1/8W-2.4K±1%-0805	1	R155	RS-05K242FT,0805S8F2401T5E，RTT05242FTP	Royalohm
8	SMD resistor -1/4W-2M±5%-1206	2	R12,R18,	RS-06K205JT,1206S4J0205T5E，RTT06205JTP	Royalohm
9	SMD resistor -1/8W-5.1K±5%-0805	1	R159	RS-05K512JT,0805S8J0512T5E，RTT05512JTP	Royalohm
10	SMD resistor -1/8W-330R±5%-0805	2	R20,R33	RS-05K331JT, 0805S8J0331T5E，RTT05331JTP	Royalohm
11	SMD resistor -1/8W-220K±5%-0805	1	R249	RS-05K224JT,0805S8J0224T5E，RTT05224JTP	Royalohm
12	SMD resistor -1/4W-620K±1%-1206	3	R17,R16,R25	RS-06K624FT, 1206S4F6203T5E，RTT06624JTP	Royalohm
13	SMD resistor -1/8W-68K±5%-0805	1	R14	RS-05K683JT,0805S8J0683T5E，RTT05683JTP	Royalohm
14	SMD resistor -1/4W-300K±5%-1206	3	R31,R28,R29	1206S4J0304T5E，RTT06304JTP	Royalohm
15	SMD resistor -1/8W-51K±1%-0805	2	R246，R248	CR21-5102-FL,0805S8F5102T5E，RTT05513FTP	ASJ, Royalohm
16	SMD resistor -1/8W-3.6K±1%-0805	2	R151,R150	0805S8F3601T5E，RTT05362FTP	Royalohm

17	SMD resistor -1/8W-56K±1%-0805	1	R152	RS-05K563FT,0805S8F0563T5E，RTT05563FTP	Royalohm
18	SMD resistor -1/4W-3.6R±1%-1206	1	R39	1206S4F03R6T5E,RS-06K3R6FT，RTT063R6FTP	Royalohm
19	SMD resistor -1/8W-100K±5%-0805	7	R42, R48, R324，R326 , R328, R330，R252	RS-05K104JT,0805S8J0104T5E，RTT05104JTP	Royalohm
20	SMD resistor -1/8W-100R±5%-0805	6	R130,R138,R231,R229,R260,R263	RS-05K101JT,0805S8J0101T5E，RTT05101JTP	Royalohm
21	SMD resistor -1/4W-0R±5%-1206	2	R262,R34	RS-06K000JT,1206S4J0000T5E，RTT06000JTP	Royalohm
22	SMD resistor -1/4W-1.2R±1%-1206	1	R163	RS-06K1R2JT,1206S4J01R2T5E，RTT061R2JTP	Royalohm
23	SMD resistor -1/8W-2K±5%-0805	2	R164,R161	RS-05K202JT,0805S8J0202T5E，RTT05202JTP	Royalohm
24	SMD resistor -1/8W-3K±5%-0805	1	R143	RS-05K302JT,0805S8J0302T5E，RTT05302JTP	Royalohm
25	SMD resistor -1/4W-3K±1%-1206	2	R134,R142	RS-06K302FT,1206S4F0302T5E，RTT06302FTP	Royalohm
26	SMD resistor -1/8W-12K±5%-0805	1	R26,	RS-05K123JT,0805S8J0123T5E，RTT05123JTP	Royalohm
27	SMD resistor -1/4W-1M±5%-1206	2	RX1，RX2	RS-06K105JT,1206S4J0105T5E，RTT06105JTP	Royalohm
28	SMD resistor -1/4W-1.5M±5%-1206	4	R255,R254,R256,R257	RS-06K155JT,1206S4J0155T5E，RTT06155JTP	Royalohm
29	SMD resistor -1/8W-47K±5%-0805	2	R49,R154	RS-05K473JT,0805S8J0473T5E，RTT05473JTP	Royalohm
30	SMD resistor -1/8W-15K±5%-0805	2	R148 R37	RS-05K153JT,0805S8J0153T5E，RTT05153JTP	Royalohm
31	SMD resistor -1/8W-1M±5%-0805	4	R45, R51,R241,R240	RS-05K105JT,0805S8J0105T5E，RTT05105JTP	Royalohm
32	SMD resistor -1/4W-200R±5%-1206	1	R261	RS-06K201JT,1206S4J0201T5E，RTT06201JTP	Royalohm
33	SMD resistor -1/8W-200K±5%-0805	1	R242	RS-05K204JT,0805S8J0204T5E，RTT05204JTP	Royalohm
34	SMD resistor -1/8W-4.7K±5%-0805	3	R30，R50，R313	RTT05472JTP	
35	SMD resistor -1/8W-20K±5%-0805	2	R157,R137	RTT05203JTP	

36	SMD resistor -1/4W-1.5R±1%-1206	1	R32	RTT061R5FTP	
37	SMD resistor -1/4W-4.7R±1%-1206	2	R15,R35	RTT064R7FTP	
38	SMD resistor -1/4W-30K±5%-1206	1	R19	RTT06303JTP	
39	SMD resistor -1/8W-3.3R±5%-0805	2	R135,R128	RTT053R3JTP	
40	SMD resistor -1/8W-2.2R±1%-0805	2	R21,R22	RTT052R2FTP	
41	SMD resistor -1/8W-3.6K±5%-0805	2	R144,R145	RTT05362JTP	
42	SMD resistor -1/8W-2.7K±5%-0805	1	R41	RTT05272JTP	
43	SMD resistor -1/8W-6.2K±5%-0805	1	R253	RTT05622JTP	
44	SMD resistor -1/8W-5.6K±1%-0805	1	R244	RTT05562FTP	
45	SMD resistor-1/8W-11K±5%-0805	3	R162,R234,R230	RTT05113JTP	
46	SMD resistor-1/8W-8.2K±5%-0805	1	R245	RTT05822JTP	
47	SMD resistor-1/8W-56K±5%-0805	5	R13,R339, R340,R341,R342	RTT05563JTP	
48	SMD resistor-1/8W-120K±5%-0805	1	R236	RTT05124JTP	
49	SMD resistor-1/8W-82K±1%-0805	1	R235	RTT05823FTP	
50	SMD resistor-1/8W-150K±5%-0805	1	R243	RTT05154JTP	
51	SMD resistor-1/8W-470K±5%-0805	1	R259	RTT05474JTP	
52	SMD resistor-1/4W-2.4M±5%-1206	2	R43,R44	RTT06245JTP	
53	SMD resistor-1/4W-24K±5%-1206	1	R258	RTT06243JTP	
54	SMD resistor-1/4W-0.62R±1%-1206	4	R308,R310,R332, R337	RTT06R62FTP	
55	SMD resistor-1/8W-18K±5%-0805	1	R153	RTT05183JTP	
56	SMD resistor-1/4W-240R±1%-1206	4	R300, R302 , R317，R320	RTT06241FTP	
57	SMD resistor-1/4W-0.68R±1%-1206	8	R306, R307, R311，R312,R333,R334，R336，R338	RTT06R68FTP	
58	SMD resistor-1/8W-430R±5%-0805	1	R149	RTT05431JTP	
59	SMD capacitor-50V-1nF±10%-X7R-0805	5	C224,C8,C24,C25，C30	08055C102KAT2A,C2012X7R1H102KT	AVX,TDK
60	SMD capacitor-50V-10nF±10%-X7R-0805	3	C138,C139,C228	08055C103KAT2A,C2012X7R1H103KT	AVX,TDK
61	SMD capacitor-50V-100nF±10%-X7R-0805	15	C12,C18,C111,C135, C134,C217,C219,C218,C220,C221, C137 C9,C29,C300,C131	08055C104KAT2A, C2012X7R1H104KT	AVX,TDK
62	SMD capacitor-50V-470pF±10%-X7R-0805	1	C10	08055C471KAT2A,C2012X7R1H471KT	AVX,TDK

63	SMD capacitor-50V-1uF±10%-X7R-0805	3	C7,C15,C222	08055C105KAT2A,C2012X7R1H105KT	AVX,TDK
64	SMD capacitor-50V-2.2nF±10%-X7R-0805	1	C227	08055C222KAT2A,C2012X7R1H222KT	AVX,TDK
65	SMD capacitor-50V-220nF-+80%-20%-Y5V-0805	2	C230,C26	08055G224ZAT2A,C2012Y5V1H224ZT	AVX,TDK
66	SMD capacitor-100V-100nF±20%-X7R-1206	1	C126	C3216X7R2A104MT	TDK
67	SMD capacitor-25V-2.2uF±10%-X7R-0805	2	C226,C140	C2012X7R1E225KT	TDK
68	SMD capacitor-100V-1uF±10%-X7R-1206	1	C128	C3216X7R2A105KT	TDK
69	SMD capacitor-25V-22nF±10%-X7R-0805	1	C127	C2012X7R1E223KT	TDK
70	SMD capacitor-50V-47nF±10%-X7R-0805	1	C229	C2012X7R1H473KT	TDK
71	SMD capacitor-50V-270PF±10%-X7R-0805	1	C132	C2012X7R1H271KT	TDK
72	SMD capacitor-50V-820PF±10%-X7R-0805	1	C225	C2012X7R1H821KT	TDK
73	Diode -1N4148W-V-75V/150mA/1.2V-SOD-123	13	D5,D11,D6,D13,D14,D103,D106,D105，D206, D102,D15,D204, D104	1N4148W-V	VISHAY
74	Diode-1N4007-M7-1000V/1A/1.1V-SMA	1	D12	1N4007-M7	TOSHIBA
75	Zener diode -30V/0.5W-±2%-SOD123	2	ZD101,ZD102	MM1ZB30	SEMTECH
76	Zener diode -5.1V/0.5W-±2%-SOD123	2	ZD103,ZD104	MM1Z5B1	SEMTECH
77	Zener diode -15V/0.5W-±5%-SOD123	2	ZD3,ZD1	MM1Z15	SEMTECH
78	Zener diode -9.1V/0.5W-±5%-SOD123	1	ZD2	MM1Z9V1	SEMTECH
79	Zener diode -5.6V/0.5W-±5%-SOD123	4	ZD300，ZD301，ZD302，ZD303	MM1Z5V6	SEMTECH
80	NPN transistor -MMBT3904-60V/0.2A/0.2W-SOT-23	3	Q2，Q3，Q4	MMBT3904LT1,MMBT3904LT1	On Semiconductor
81	PNP transistor -BCX53-[-80V]/1A/0.5W-1.25W-SOT-89	2	Q113,Q115	BCX53	INFINEON
82	NPN transistor -BCX56-80V/1A/0.5W-1.25W-SOT-89	2	Q116,Q114	BCX56	INFINEON
83	Dual 4 A peak high speed low-side power MOSFET driver - UCC27324D-4A-SO-8	1	IC102		TI
84	NPN transistor-BDP953-100V/3A/5W-SOT-223	4	Q300, Q301, Q302，Q303		INFINEON
85	Operational Amplifer-LM358DR-SO-8	1	IC105	LM358DR	TI

86	Optocouple -BPC-817SC-CTR200%~400%-SOP4	3	IC103,IC4,IC106	BPC-817SC,BPC-817SC,BPC-817SC	
87	Adjustable precision shunt regulator -AZ431AN-ATRE1-36V-0.4mA-SOT23-BCD	2	IC5,IC104	AZ431AN	BCD
88	PFC controller -TDA4863-SO-8	1	IC1	TDA4863	INFINEON
89	BRIDGE DRIVER HIGH/LOW SIDE, L6385D -0.4A-SO-8	1	IC202	L6385D	ST
90	LLC controller-ICE2HS01G-PG-DSO-20	1	IC203		INFINEON
91	Linear LED driver BCR450 SC74	4	IC300，IC301，IC302, IC303	BCR450	INFINEON
92	Metal Oxide Film Resistors -3W-0.15R±5%	1	R24	RSS3WJ0R15	
93	Carbon resistor -10D471K-470V-2500A-Φ10mm-P=7.5mm	1	RV1	STE-10D-471K	
94	Thermistor -SCK102R55MSY-2.5R-5A-NTC-Φ10*6mm-P=5mm	1	RT1	SCK102R55AMSY	Skyking
95	Thermistor -TTC05104KSY-100K±10%-NTC-Φ5*5mm-P=3.5mm	1	RT2	TTC05104KSY(RoHS)	
96	Electrolytic capacitor -50V-22uF±20%-Φ5*11mm-P=2.0mm-105℃-YXF	1	C17	50YXF22M5X11	Rubycon
97	Electrolytic capacitor - 35V-47uF±20%-Φ6.3*11mm-P=2.0mm-105℃-YXF	3	C11,C19,C21	35YXF47M6.3X11	Rubycon
98	Electrolytic capacitor -450V-100uF±20%-Φ18*35mm-P=7.5mm-105℃-TXW	1	C14	450TXW100M18X35	Rubycon
99	Electrolytic capacitor -63V-1000uF±20%-Φ16*25mm-P=7.5mm-105℃-YXA	2	C124,C125	63YXA1000M16X25	Rubycon
100	Electrolytic capacitor -16V-100uF±20%-Φ5*11mm-P=2.0mm-105℃-YXA	2	C22,C23	16YXA100M5X11	Rubycon
101	Electrolytic capacitor -50V-10uF±20%-Φ5*11mm-P=2.0mm-105℃-YXA	1	C110	50YXA10M5X11	Rubycon
102	Metal film capacitors -450V-470nF±10%-11.5*16.0*8.0mm-P=10.0mm	2	C5,C6	MMC 474K/450V(400V) 15MM	
103	Metal film capacitors -450V-47nF±10%-11.5*12.0*5.0mm-P=10.0mm	1	C28		NISSEI
104	Metal film capacitors -630V-33nF±5%-18*6.0*12mm-P=15mm R76	1	C122	R76PI2330JE3EJ	Arcotronics

105	Ceramic capacitors -1KV-220pF±10%-Y5P-Φ5.5-P=5.0mm	1	C231	221/1KV，1KV-Y5P-221K，Y5P221K3A	
106	Ceramic capacitors - 1KV-2.2nF±20%-Y5U-Φ5.5-P=5.0mm	3	C13,C20,C16	222/1KV，1KV-Y5V-222M	
107	X2 capacitor-275VAC-470nF±10%-18*16*10mm-P=15mm	1	CX2	X2 474K/275VAC15MM 18*16*10,MPX275 X2 474K 18*16*10 P=15	
108	X2 Capacitor -275VAC-220nF±10%-18*16*9.5mm-P=15mm	1	CX1	X2 224K/275VAC15MM 18*14.5*8.5,MPX275 X2 224K 18*14.5*8.5 P=15	
109	Y1 Capacitor -250VAC-2.2nF±20%-Y5U-Φ8.5-P=10.0mm	4	CY1,CY2,CY3,C31	CD222M	
110	Power transformer - WNP15042L T301-22:15-L=3.0mH±20%-T14*8*7	1	T103		
111	High-frequency transformer - WNP12048LM4D T102-38:7-L=800uH±10%-PQ3225	1	T102		
112	High-frequency transformer - WNP12048LM4D T1－132:12－L=2.0mH±10%-EE1614	1	T1		
113	Ring inductor -WNP15042L L1-150uH±10%-26A-T68	1	L2	HHA-T60-26-90421,HJS T6026-001	
114	PFC Inductor -WNP15042L L202-300uH±10%-PQ2625	1	L1	WNP15042L L202	
115	Resonant inductor - WNP12048LM4D L101-80uH±10%-RM8	1	L101		
116	Common mode Choke - WNP15042L LF2-2-15mH(min)-2A-T16*12*8	1	LF1	HHA-T16*12*8-90413,	
117	Common mode Choke - WNP15042L LF1-2-12mH(min)-2A-T22*14*8	1	LF2	FOTC2105501100A	
118	Superfast Recovery Diode - STTH3L06-600V/3A/1.3V/85nS-DO-201AD	1	D4	STTH3L06	ST
119	Rectifier -1N5408G-1000V/3.0A/1.1V-DO-201AD	1	D3	1N5408G	GULFSEMI
120	Fast Recovery Diode-HER107G-1000V/1.0A/1.3V/250nS-DO-41 75NS	1	D8	HER107G	GULFSEMI
121	Fast Recovery Diode-HER104G-400V/1.0A/1.3V/250nS-DO-41 75NS	3	D7,D9,D10	HER104G	GULFSEMI
122	Bridge -GBU606-600V/6A/1.0V-GBU	1	BR1	GBU606	SEP
123	NPN Transistor -2N3904-60V/0.2A/0.625W-T0-92	1	Q5	2N3904	Fairchild
124	N MOS-IPA60R190E6-600V/20.2A/0.19Ω±20V-TO220F	1	Q1	IPA60R190E6	INFINEON

125	N MOS-IPA60R380C6-600V/10.6A/0.38Ω±30V-PG-TO-220F	2	Q108 Q111	IPA60R380C6	INFINEON
126	N MOS-IPP110N20N3G-200V/88A/0.011Ω-PG-TO-220	2	Q109 Q112	IPP110N20N3G	INFINEON
127	CoolSET IC-ICE3B0365J -DIP-8-6	1	IC2	ICE3B0365J	INFINEON
128	POSITIVE VOLTAGE REGULATORS -L78L05AB-5V-100mA-T0-92	1	IC3	L78L05AB	ST
129	Fuse and - Cartridge fuse -250V-3.15A-Φ3.6*10mm-Slow break down type -ceramic materials	1	F1	ICP3.15A250V	

4.4.2 BOM list for XC824 daughter card

No	Component Description	Qty	Designator	Part Number	Manufacturer
1	Daughter Board -WNP12048LM4D_DB1_X824 VER:03 FR-4,1 Ounce -36*22*1mm	1			
2	SMD Capacitor -50V-100nF±10%-X7R-0805	3	C1，C5，C8	08055C104KAT2A,C2012X7R1H104KT	AVX,TDK
3	SMD Capacitor -25V-330pF±10%-X7R-0805	4	C6,C7，C9，C10	08053C331KAT2A,C2012X7R1E331KT	AVX,TDK
4	micro-controller -XC824-48MHz-INFINEON-DSO-20	1	U1	XC824	INFINEON
5	Pin - square head -14P / single row / clubfoot / 2.54 / P = 2.54/4.8	1	CON2		

4.4.3 BOM list for XC835 daughter card

No	Component Description	Qty	Designator	Part Number	Manufacturer
1	Daughter board -WNP12048LM4D_DB2_XC835 VER:03 FR-4,1 Ounce -51*24*1mm	1			
2	SMD Resistor -1/8W-0R±5%-0805	1	R6	RS-05K000JT,0805S8J0000T5E，RTT05000JTP	Royalohm
3	SMD Resistor -1/8W-10K±5%-0805	1	R9	RS-05K103JT,0805S8J0103T5E，RTT05103JTP	Royalohm
4	SMD Resistor -1/8W-3.3K±5%-0805	1	R4	RS-05K332JT,0805S8J0332T5E，RTT05332JTP	Royalohm

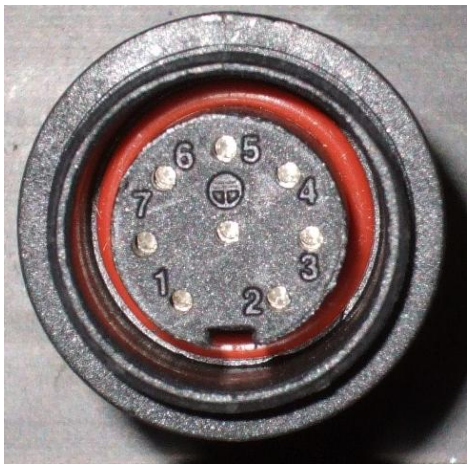
5	SMD Resistor -1/4W-0R±5%-1206	1	R7	RS-06K000JT,1206S4J0000T5E，RTT06000JTP	Royalohm
6	SMD resistor -1/8W-330R±5%-0805	1	R3	RS-05K331JT, 0805S8J0331T5E，RTT05331JTP	Royalohm
7	SMD Resistor -1/8W-1K±1%-0805	1	R2	RS-05K102FT,0805S8F0102T5E，RTT05102FTP	Royalohm
8	SMD Resistor -1/8W-4.7R±5%-0805	1	R5	RTT054R7JTP	
9	SMD Resistor -1/8W-11K±5%-0805	1	R8	RTT05113JTP	
10	SMD Capacitor -35V-22UF±20%-Φ6.3*5.5mm-105℃，P=2.5-JKV	1	C11		Rubycon
11	SMD Capacito -25V-330pF±10%-X7R-0805	4	C6,C7,C9,C10	08053C331KAT2A,C2012X7R1E331KT	AVX,TDK
12	SMD Capacito -50V-100nF-+80%-20%-Y5V-0805	3	C1,C5,C8	08055G104ZAT2A,C2012Y5V1H104ZT	AVX,TDK
13	Diode -1N4148W-V-75V/150mA/1.2V-SOD-123	1	D1	1N4148W-V	VISHAY
14	Bridge -MB6S-600V/0.5A/1.1V-4.7*7.0*2.5mm	1	BRD1	MB6S	SEP
15	Zener diode -3.3V/0.5W-±2%-SOD123		D2	MM1Z3B3	SEMTECH
16	NPN Transistor -MMBT3904-60V/0.2A/0.2W-SOT-23	1	Q1	MMBT3904LT1,MMBT3904LT1	On Semiconductor
17	Optocouple -BPC-817SC-CTR200%~400%-SOP4	2	U1,U2	BPC-817SC,BPC-817SC,BPC-817SC	
18	Micro-controller -XC835-48MHz-INFINEON-DSO-24	1	U3	XC835	INFINEON
19	connector - square hole - Single row of pin 14 pins /90 degree /2.54/P=2.54/4.8	1	CON1		

4.5 Wiring connection to LED lamp

Before connecting to the LED Lamp, the following need to be checked:

- All LED modules need to have a minimum current greater then 680mA.
- Total forward voltage of all LED modules must be within power supply output voltage range (refer to technical specification).
- Do not connect the power supply to different LED module type
- For efficiency consideration, the total forward voltage difference between all LED modules should be less than3V.

Connections of the 4 channels LED light module to the power supplies are through a 8-pins connectors shown in 0. The routing for such connections are descript in the pin configuration below.



Pin 1: LED1- (Black)
Pin 2: LED1+ (White)

Pin 3: LED2+ (Red)
Pin 4: LED2- (Silver)

Pin 5: LED3- (Blue)
Pin 6: LED3+ (Yellow)

Pin 7: LED4+ (Green)
Pin 8: LED4- (Black&White)

Figure 26 8-pin LED power supplies connection

5 System Performance Data

5.1 Total System Efficiency

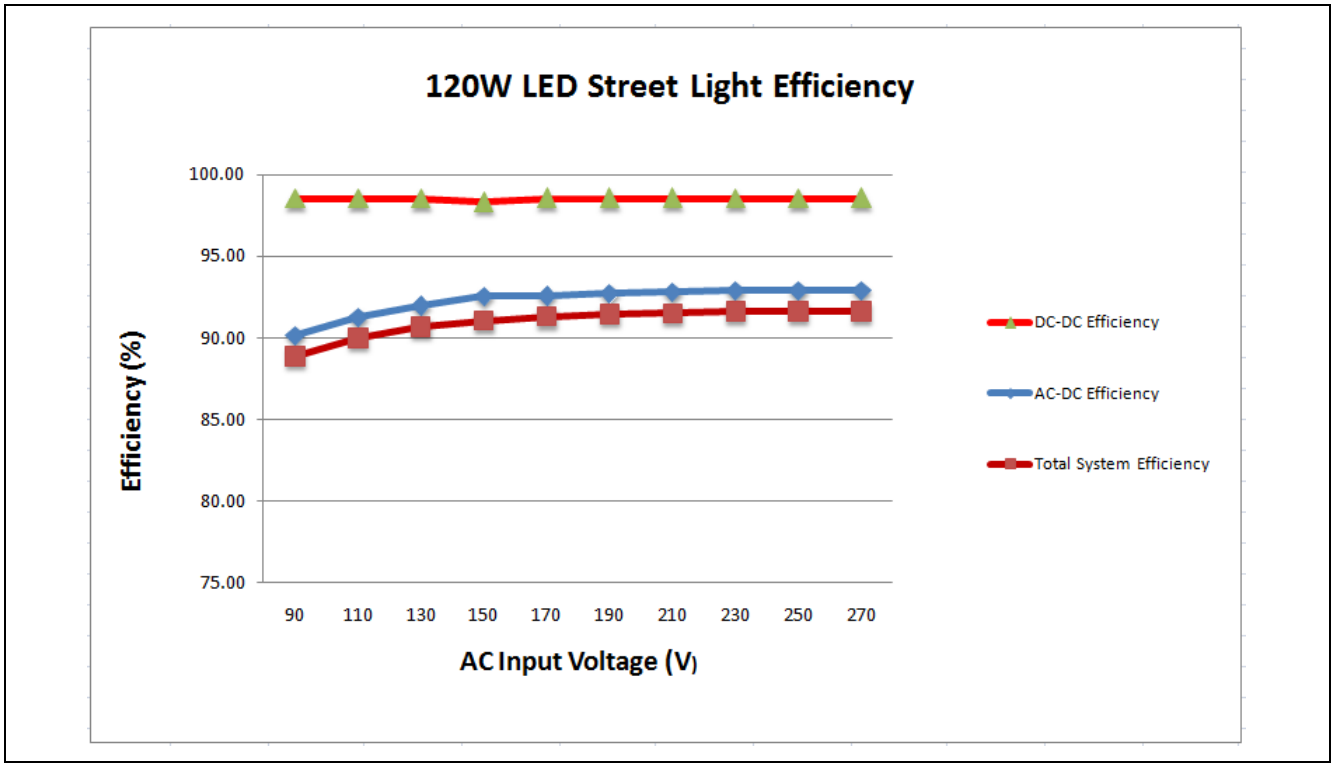


Figure 27 Total System Efficiency

5.2 Power Rating

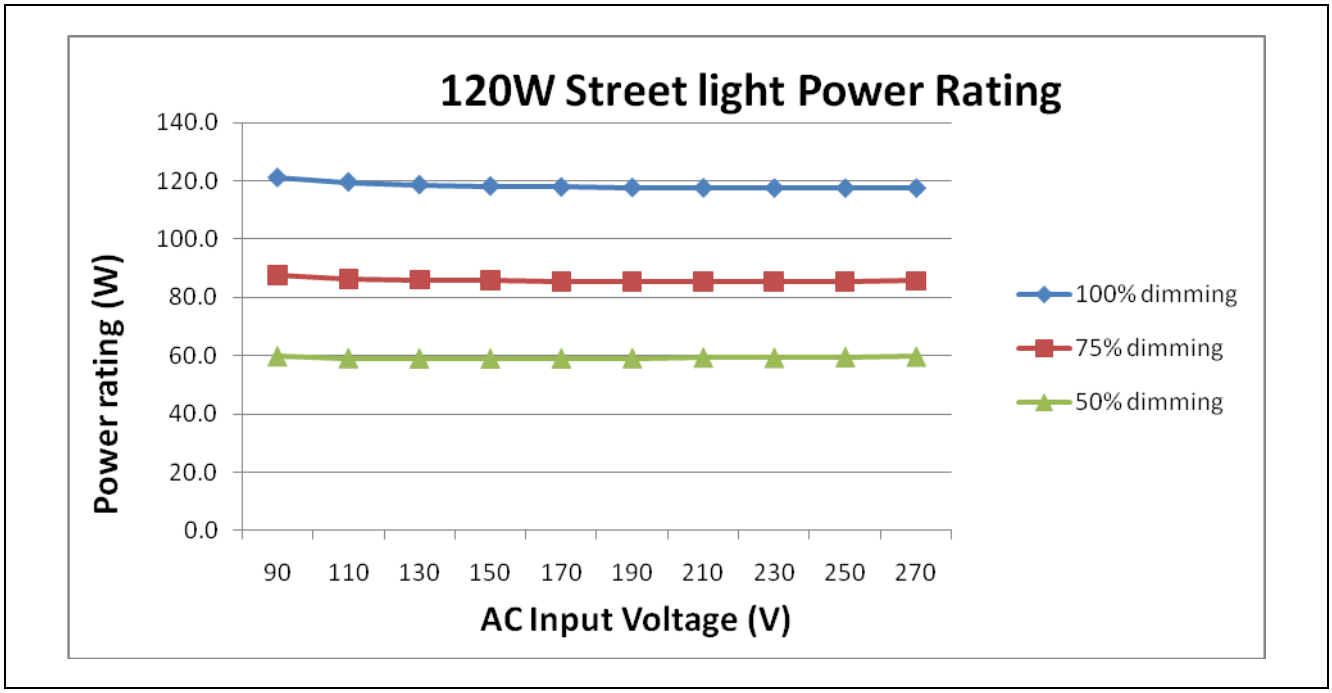


Figure 28 Power Rating

5.3 Total Harmonic Distortion (THD)

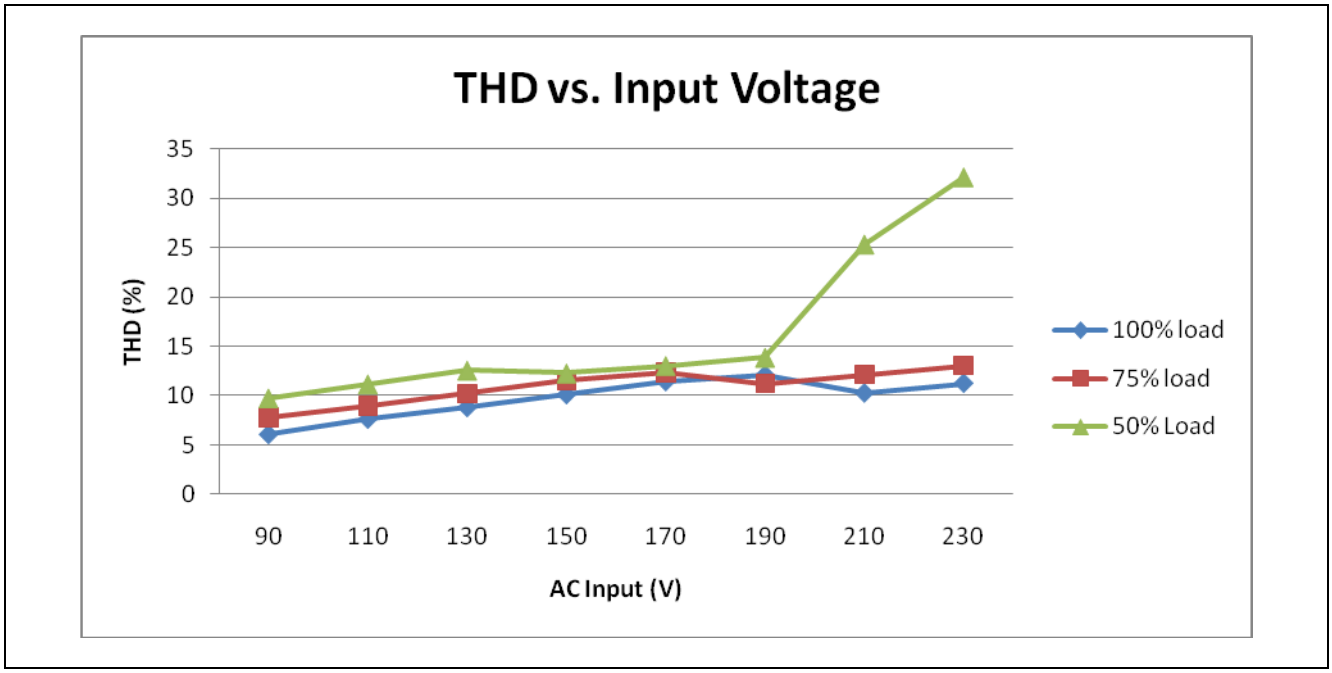


Figure 29 THD Measurement

5.4 Power Factor

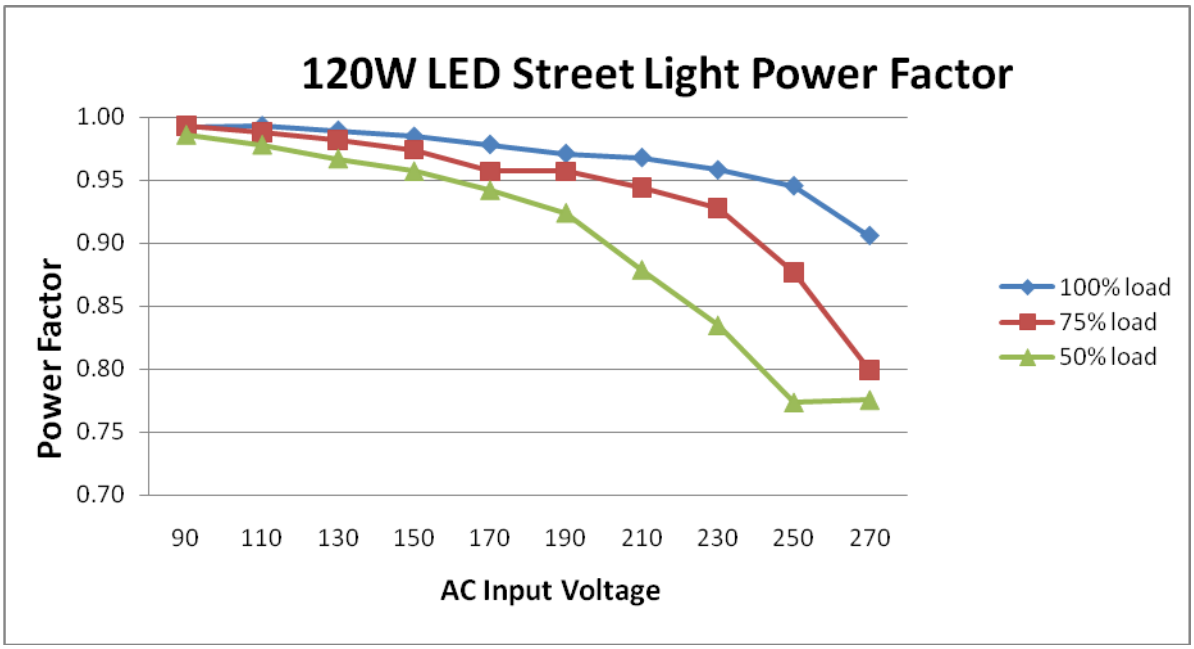


Figure 30 Power Factor Measurement

6 References

The following documents can be obtained from www.infineon.com.

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  http://www.infineon.com/cms/en/product/channel.html?channel=ff80808112ab681d0112ab6a8b78055a&tab=2.
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- AP08102 DALI Control Gear Software Stack
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