XC800 Family

DALI Dimmable Fluorescent Lamp Ballast

AP08134

Application Note

V1.0, 2012-07

Microcontrollers

Edition 2012-07

Published by
Infineon Technologies AG
81726 Munich, Germany

LEGAL DISCLAIMER

THE INFORMATION GIVEN IN THIS APPLICATION NOTE IS GIVEN AS A HINT FOR THE IMPLEMENTATION OF THE INFINEON TECHNOLOGIES COMPONENT ONLY AND SHALL NOT BE REGARDED AS ANY DESCRIPTION OR WARRANTY OF A CERTAIN FUNCTIONALITY, CONDITION OR QUALITY OF THE INFINEON TECHNOLOGIES COMPONENT. THE RECIPIENT OF THIS APPLICATION NOTE MUST VERIFY ANY FUNCTION DESCRIBED HEREIN IN THE REAL APPLICATION. INFINEON TECHNOLOGIES HEREBY DISCLAIMS ANY AND ALL WARRANTIES AND LIABILITIES OF ANY KIND (INCLUDING WITHOUT LIMITATION WARRANTIES OF NON-INFRINGEMENT OF INTELLECTUAL PROPERTY RIGHTS OF ANY THIRD PARTY) WITH RESPECT TO ANY AND ALL INFORMATION GIVEN IN THIS APPLICATION NOTE.

Information

For further information on technology, delivery terms and conditions and prices, please contact the nearest Infineon Technologies Office (**www.infineon.com**).

Warnings

Due to technical requirements, components may contain dangerous substances. For information on the types in question, please contact the nearest Infineon Technologies Office.

Infineon Technologies components may be used in life-support devices or systems only with the express written approval of Infineon Technologies, if a failure of such components can reasonably be expected to cause the failure of that life-support device or system or to affect the safety or effectiveness of that device or system. Life support devices or systems are intended to be implanted in the human body or to support and/or maintain and sustain and/or protect human life. If they fail, it is reasonable to assume that the health of the user or other persons may be endangered.

XC83x
Revision History: V1.0 2012-07

Previous Version(s): -

Page	Subjects (major changes since last revision)
-	-

Trademarks

We Listen to Your Comments
Is there any information in this document that you feel is wrong, unclear or missing? Your feedback will help us to continuously improve the quality of this document. Please send your proposal (including a reference to this document) to:
mcdocu.comments@infineon.com

Table of Contents

1 Overview

Digital Addressable Lighting Interface (DALI) is a communication protocol for lighting control in buildings. The interface was first described in Annex E, IEC60929 standard for fluorescent lamp ballast. Subsequently, it was updated to the new standard IEC-62386, to include other lighting devices, such as LED, HID, and so on. The complete standard for control interface of electronic control gears was published in June 2009. The standard for lighting control devices is scheduled to be published in September 2012.

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 bi-directional 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.

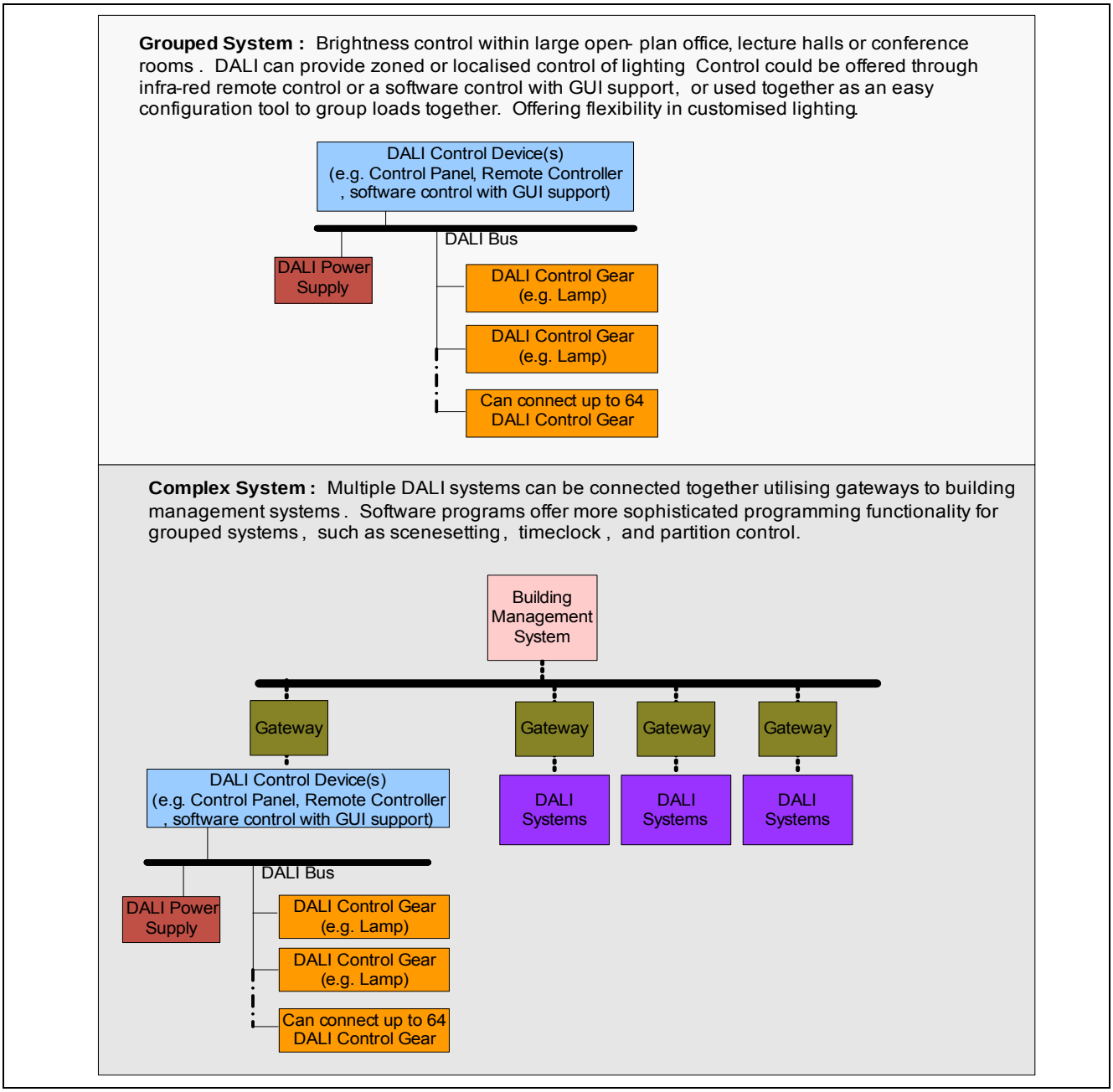


Figure 1 DALI system types

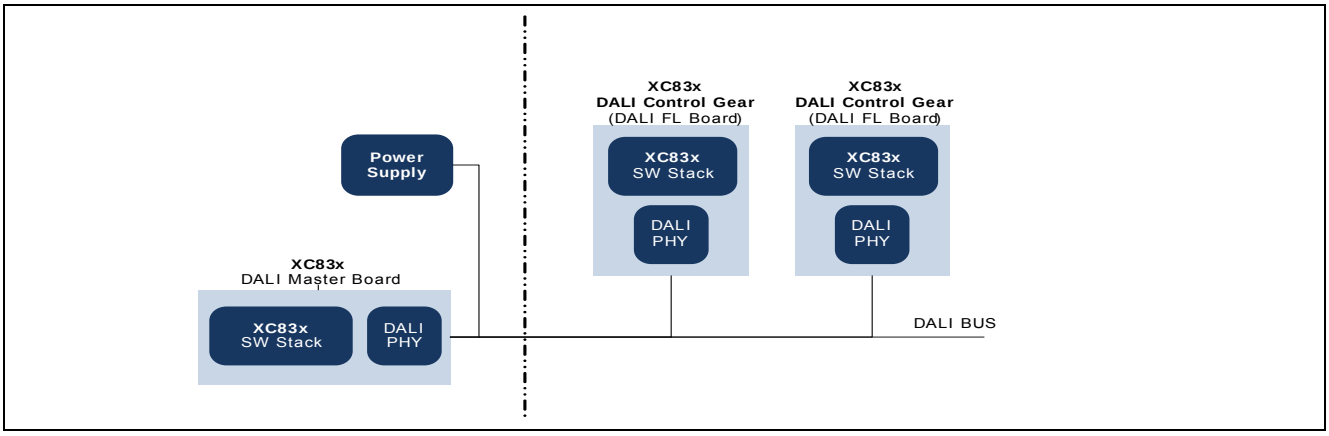


Figure 2 Block Diagram for DALI Control Device and Control Gear

This document describes a digital dimming example implementation using DALI for a fluorescent lamp ballast.

The following items are required for use with this application note:

- 1x XC836 Easy Kit (to serve as a DALI Control Device; KIT_XC836_EK_V1)
- 1x DALI PHY (KIT_XC822_XC836_DALI)
- 1 set of DALI Fluorescent Ballast (KIT_DALI_FL_XC836_DKV1)
- Infineon DALI LightNet tool (AP08104: Guide to using DALI LightNet tool)

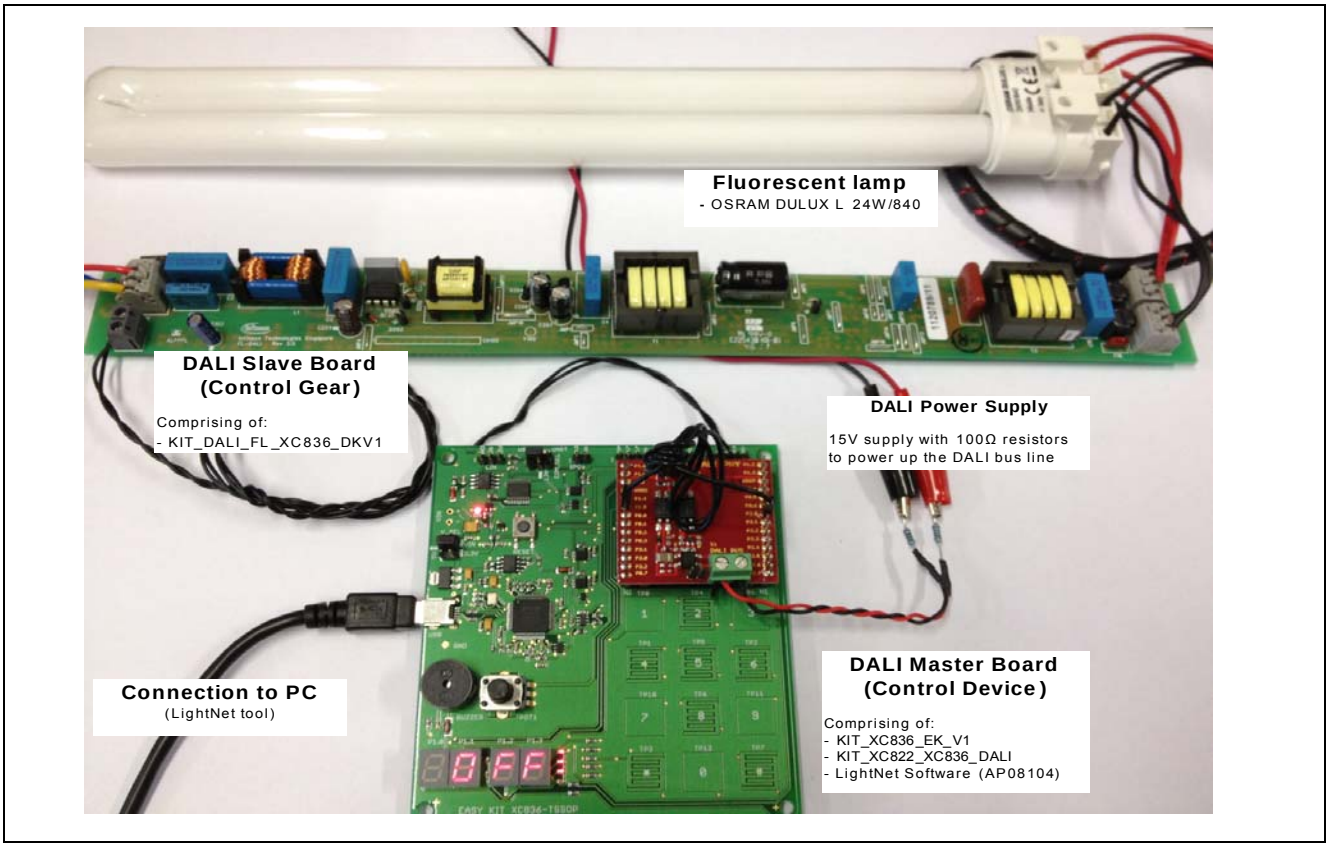


Figure 3 Setup for DALI Fluorescent Lamp Ballast

2 Design Specification

This demo board has been designed according to the specifications given in **Table 1**.

Table 1 Demo Board Design Specification

Design Parameters	Values
Line Voltage(V)	90 - 265
Line Frequency (Hz)	50/60
Lamp Type	OSRAM Dulux L 24 W
Lamp Power @ Maximum Brightness (W)	24
Input Power @ Maximum Brightness (W)	27
Running Frequency (kHz)	44
DC Bus Voltage	400
Dimming Interface	DALI
Dimming Range	5% - 100%
Standby Power	<1W

3 Hardware Modules

Currently, the market for brightness control in electronic ballast is dominated by 1-10V interfaces (See Infineon AN-ICB2FL02G Smart Ballast Control IC for Fluorescent Lamp Ballasts). The problem is that electronic ballasts cannot be individually addressed when a 1-10V interface is used. DALI is a solution for this problem because it is a standardized digital protocol with which illuminating devices can be controlled individually via addresses.

The previous AN-ICB2FL02G solution has been updated to provide DALI with an auxiliary power supply (CoolSET - ICE3BR4765J) and a microcontroller (XC836).

The auxiliary power supply provides current to the ballast controller, MCU and peripheral circuits.

The microcontroller receives and decodes the lighting control command through the DALI interface, and also controls the ballast IC to implement the dimming function and control on/off commands.

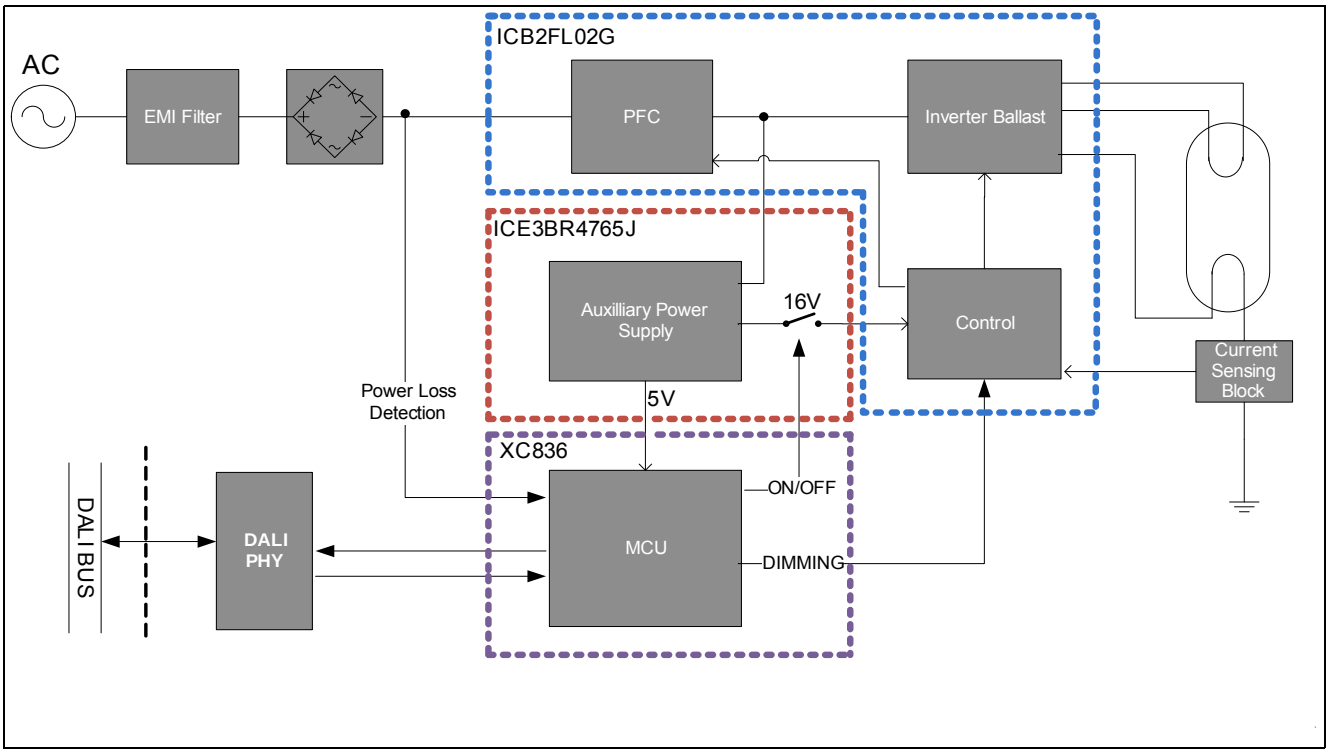


Figure 4 Block diagram view - Fluorescent Ballast with DALI solution

3.1 Smart Ballast Controller - ICB2FL02G

The fluorescent lamp ballast controller ICB2FL02G is designed to control both a PFC boost converter and a half-bridge inverter to drive a fluorescent lamp. It's intelligent control concept enables designers to develop cost-effective dimmable ballasts for fluorescent lamps (FL) that fulfil the requirements of high performance ballast. The ballast controller ICB2FL02G has an improved and enlarged functionality that enables dimmable and high quality single or multi lamp ballasts with a low number of external components. It's advanced features help save system costs, enhances system reliability, and reach class A2 of the energy efficiency index (EEI) for fluorescent lamp ballasts easily.

In this design, ICB2FL02G works with an onboard microcontroller (XC836) to achieve DALI control. The on/off control is realised by simply turning on/off the Vcc supply for the ballast controller, while the dimming control is handled by regulating the inverter working frequency and therefore adjusting the lamp current. To change the working frequency during operation, it is necessary to influence the resistance at the RFRUN pin. A voltage of 2.5V is provided at the pin from the IC. The current drawn from the pin is measured by the IC and the working frequency is then varied accordingly. A higher current results in a higher working frequency and the lamp current is reduced due to the change in load-circuit impedance.

The minimum dimming level is as low as 3% of the maximum lamp current. For a detailed explanation of dimming control, please refer to the DALI standards “IEC 62386 Digital addressable lighting interface; Part 101 and Part 102”.

3.1.1 Dimming Operation Principle

The dimming concept uses a regulator to control the lamp current by adjusting the running frequency. For close loop control it is necessary to sense the lamp current, which is achieved with a combination of a shunt resistor and diode, as shown in the application schematic. The target current value is set with the DALI Master. Through the DALI interface, the onboard microcontroller (XC836) will decode the dimming command and produce a corresponding PWM signal with 100 kHz. In correspondence to the dimming level, the PWM duty cycle changes from 100% (for 100% dimming) to 0% (for 5% dimming). The PWM output is filtered with an RC filter. The resulting DC voltage feeds the negative input of an operational amplifier (Op-Amp), to serve as the lamp current reference. The Op-Amp is configured as a PI-Regulator to control a NPN transistor to influence the impedance at the RFRUN pin and consequently change the inverter running frequency. As a result, a new lamp current is set to the desired level.

3.2 Auxiliary Power Supply

An auxiliary power supply is necessary to power-up the whole system, including the on-board microcontroller (XC836), Op-Amp as well as the ballast controller. Infineon’s CoolSET IC (ICE3BR3765J), which integrates a current mode PWM controller and a high voltage power MOSFET with comprehensive protection feaures, is used for this low cost, compact, yet reliable power supply. The design specification of the auxiliary power supply is listed in the following table.

Table 2 Auxiliary Power Supply Design Specification

Design Parameters	Values
Line Voltage(V)	90 - 265
Line Frequency (Hz)	50/60
Output 1	16.5V / 0.2A
Output 2	5V / 0.5A
Efficiency	>75%
Switching Frequency (kHz)	65
Output Ripple Voltage	<100mV (exclude high frequency spike)
Protection	Open loop, short circuit over temperature

3.3 XC800 Microcontroller - XC836

The XC800 family of microcontrollers from Infineon is based on the 8051 architecture, and has a set of peripherals that enables it to be used in real-time control environments such as motor control, as well as for communication purposes. In this solution, XC836 is selected to provide DALI communication, power brownout detection control and channel dimming control.

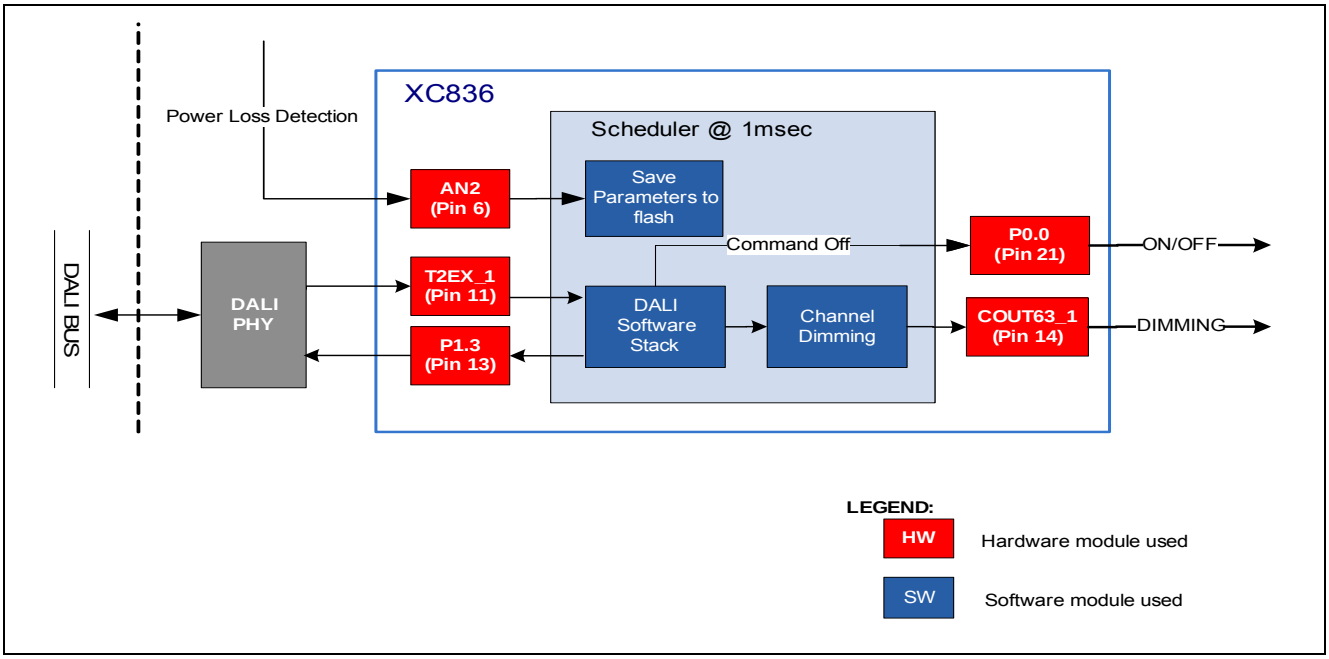


Figure 5 XC836 function overview

3.3.1 DALI Communication

The control line voltage in a DALI system is normally 15V (between 22.4 and 9.5 volts) when there is no communication (idle state). A DALI PHY has been constructed to translate the DALI signals to the microcontroller levels where a DALI software stack is then used to manage the incoming and outgoing DALI communication frames. The DALI software stack has implemented all the commands in IEC 62386 - Part 102.

More information is available in the application note “AP08102 DALI Control Gear Software Stack”.

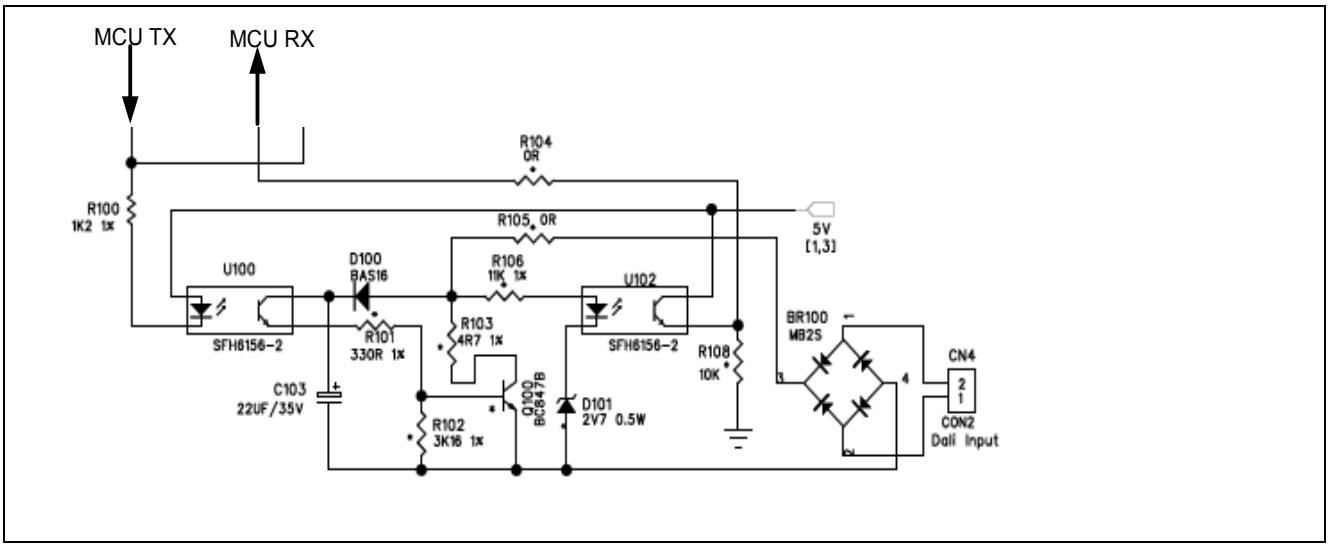


Figure 6 DALI PHY circuit

3.3.2 Power Loss Detection

The rectified input voltage is sensed through a voltage divider by the microcontroller's ADC. A loss of power event is detected when the input voltage drops below 0.6 volts. When such an event is detected user parameters will be saved.

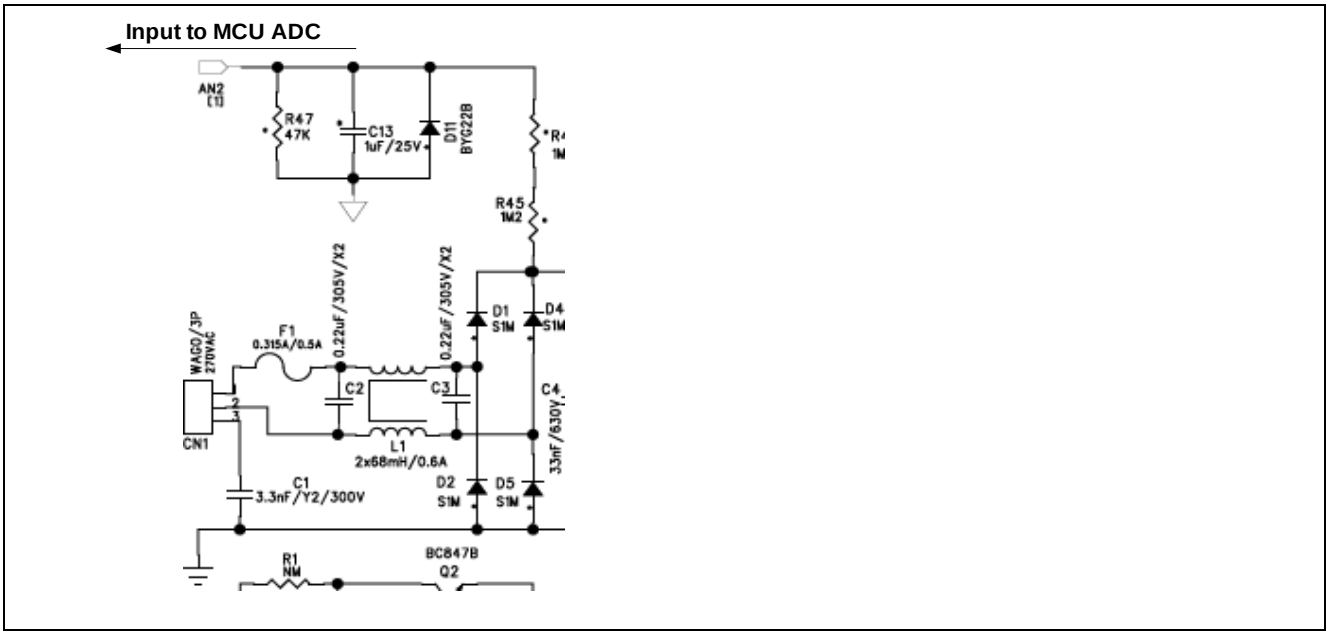


Figure 7 Power loss detection mechanism

3.3.3 Dimming Characteristics

The minimum and maximum brightness is set to 35 and 250 respectively, resulting in a dimming curve as shown.

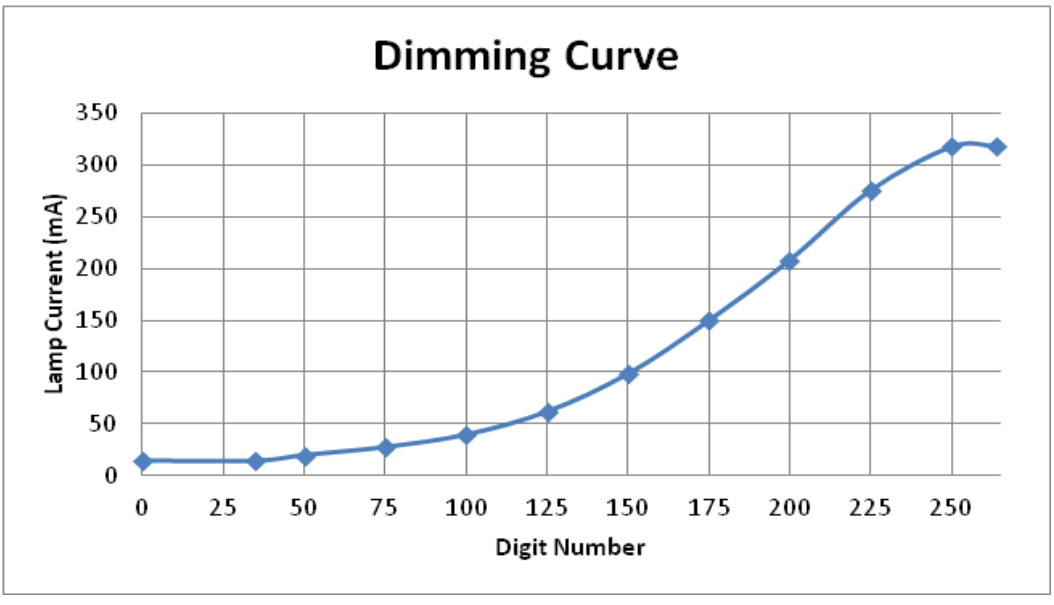


Figure 8 Dimming profile

4 Hardware Setup

The hardware setup for this example application is described here.

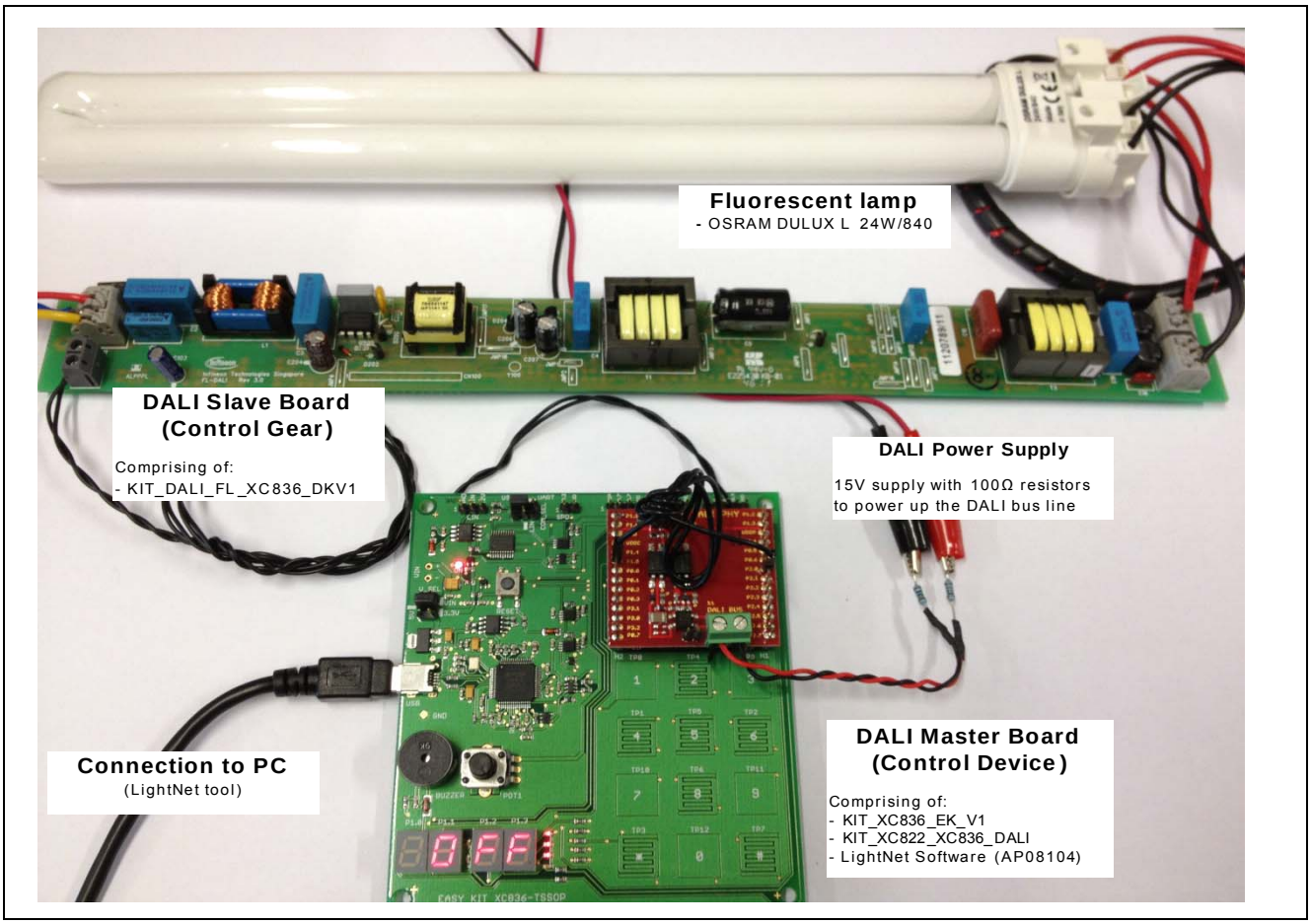


Figure 9 Hardware Setup for Infineon Control Device and Control Gear

4.1 Setting up the DALI Control Device

The DALI Software for Control Device has been developed to support the use of the LightNet tool and can work on XC836 Easy Kit boards. This software must be downloaded to the XC836 Easy Kit board prior to calling the LightNet tool. (File: AP0810413_LightNet_XC800Master_code.exe) Touchpad control is also available. For further details on setting up the DALI Control Device and LightNet tool, please refer to *AP08104 Guide to using DALI LightNet tool.*

To use the XC836 Easy Kit board as the LightNet DALI Control Device, connect and download the generated hexfile (Lightnet_XC800Master.hex) to the XC836 Easy Kit board using XC800 FLOAD in DAVEBENCH™ or KEIL UVision4.

Note: Please ensure that the device is configured to User Mode Diagnostic, and that the COM_SEL settings is set to USB.

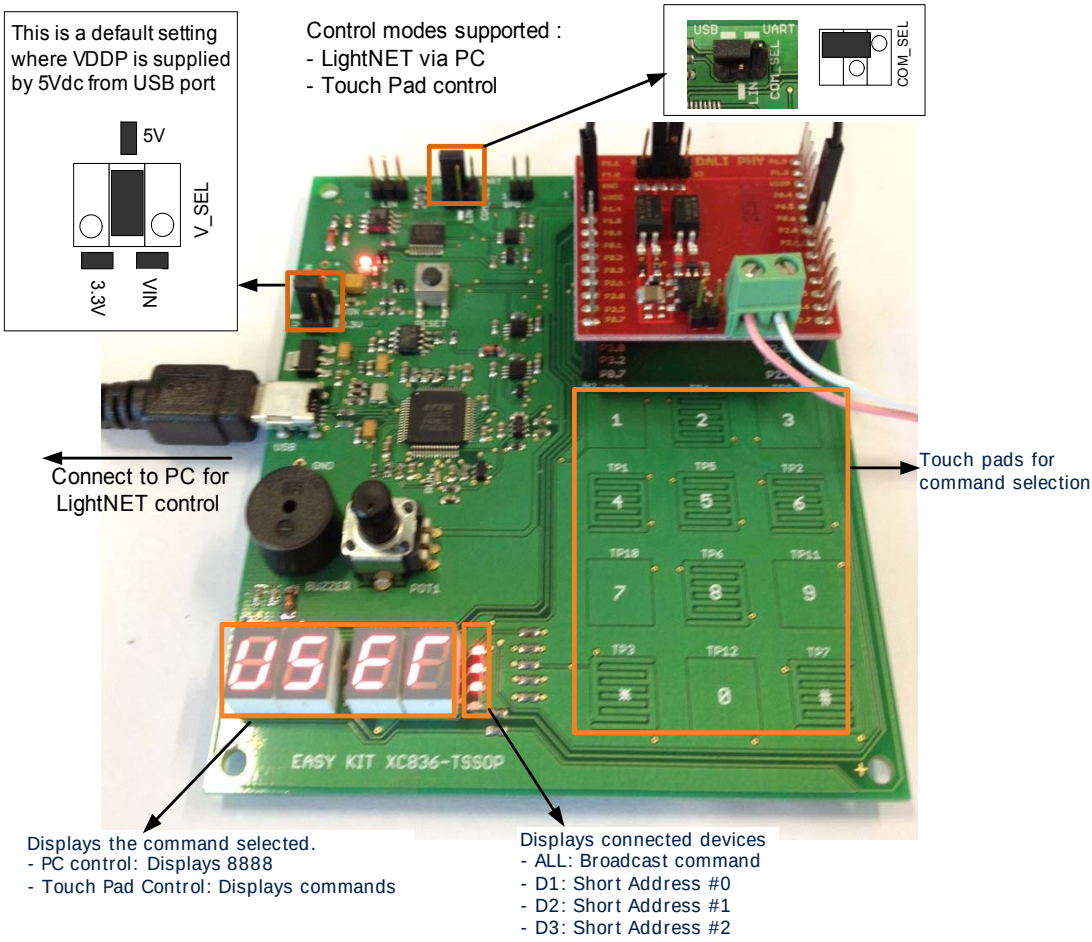


Figure 10 Overview of DALI Master (Control Device)

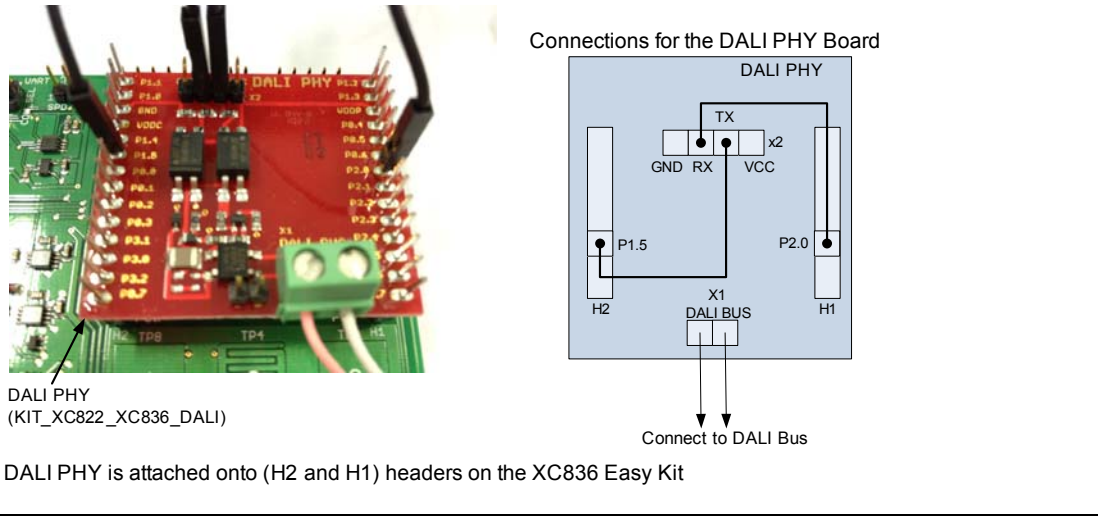


Figure 11 DALI PHY connection for XC836 Easy Kit

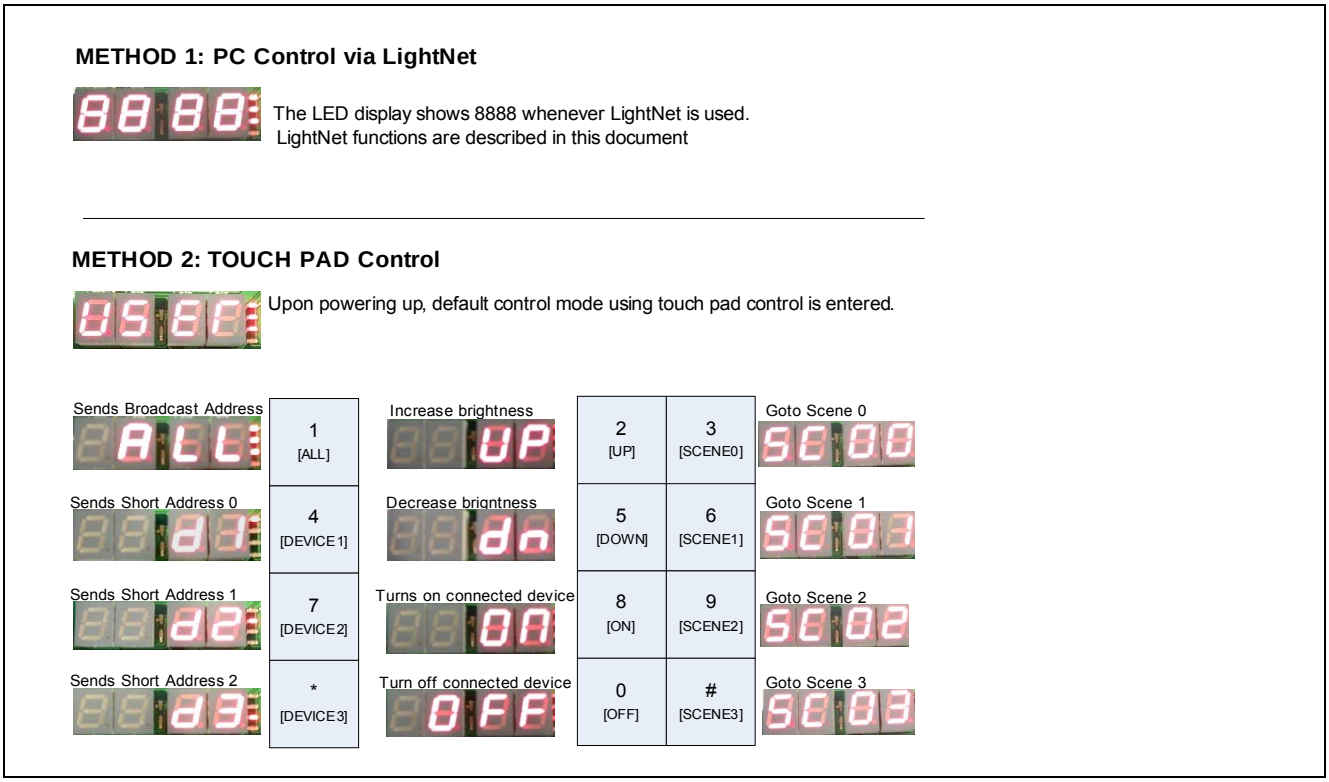


Figure 12 DALI Control using PC and Touch Pad description

4.2 Setting up the DALI Fluorescent Lamp Ballast

The hardware for the control device and control gear is set up as follows:

1. The DALI Fluorescent Lamp (KIT_DALI_FL_XC836_DKV1) has been pre-loaded with DALI Control Gear Software Stack (Control Gear file: AP08134_v1_0_FLSlave.hex). If a user intends to customise this solution, the DAP MiniWiggler can be connected to the DALI Control board to download the generated hexfile using XC800 FLOAD in DAVEBENCH™ or KEIL UVision4. For further details on the DALI Control gear software, please refer to *AP102 DALI Control Gear Software Stack*.
2. To supply power for the DALI bus, connect 100Ω resistors in series to each terminal of a power supply unit supplying 15VDC. This supplies the DALI bus for the DALI network devices.
3. Connect the DALI Control Device (Master) and Control Gear (Slave) to the DALI bus. This completes the DALI setup to control the device!

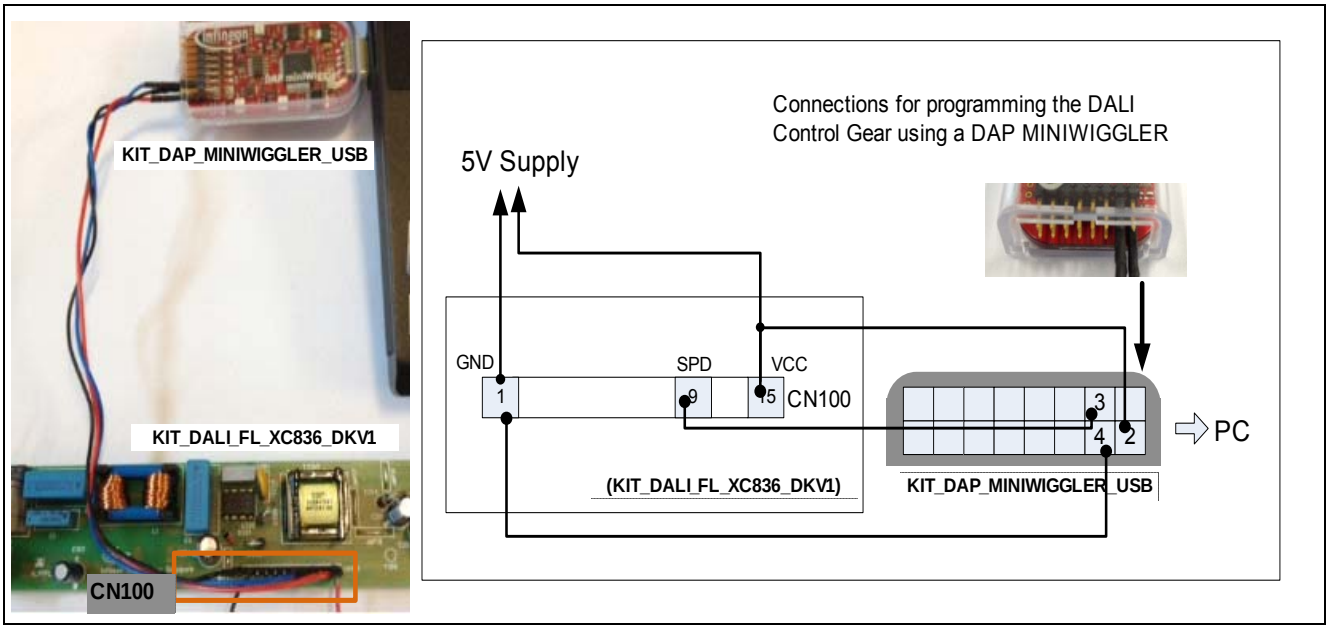


Figure 13 Programming the DALI FL Board using the DAP MiniWiggler

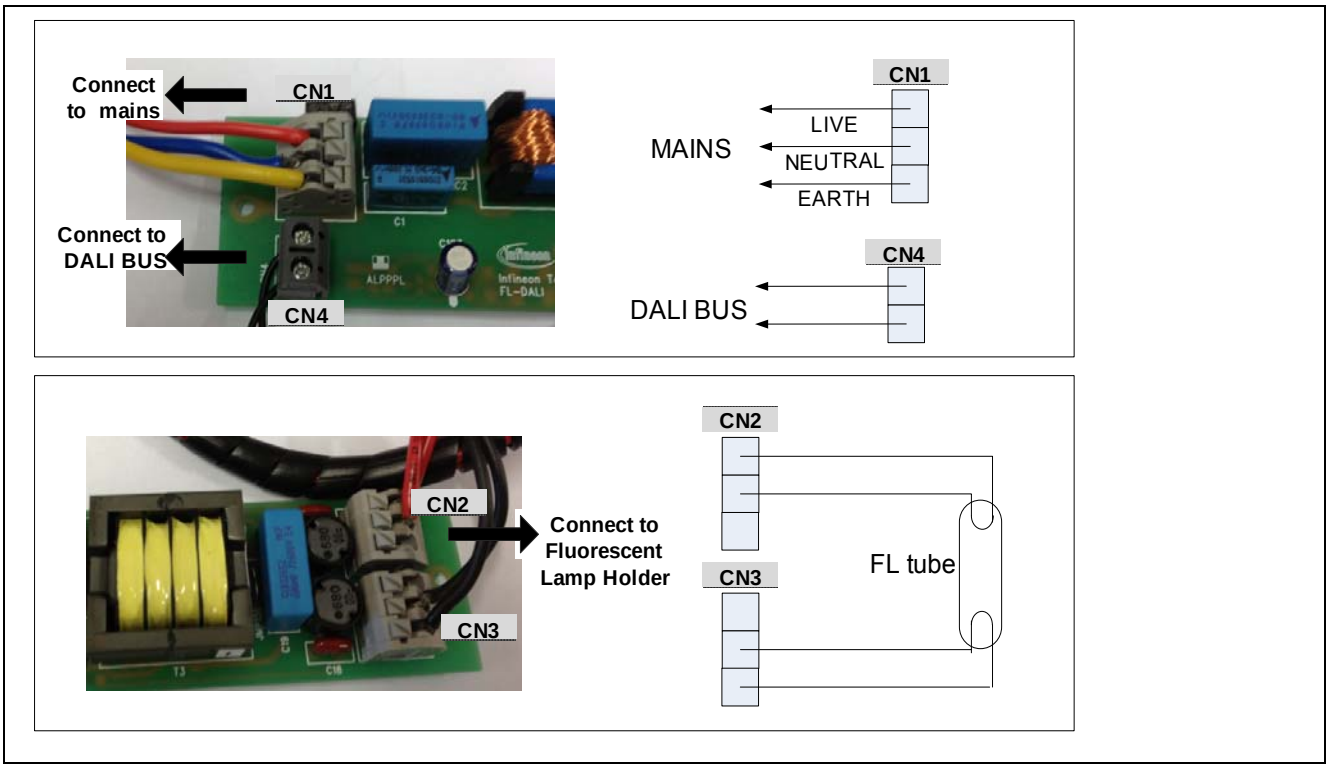


Figure 14 Connecting the DALI FL Board

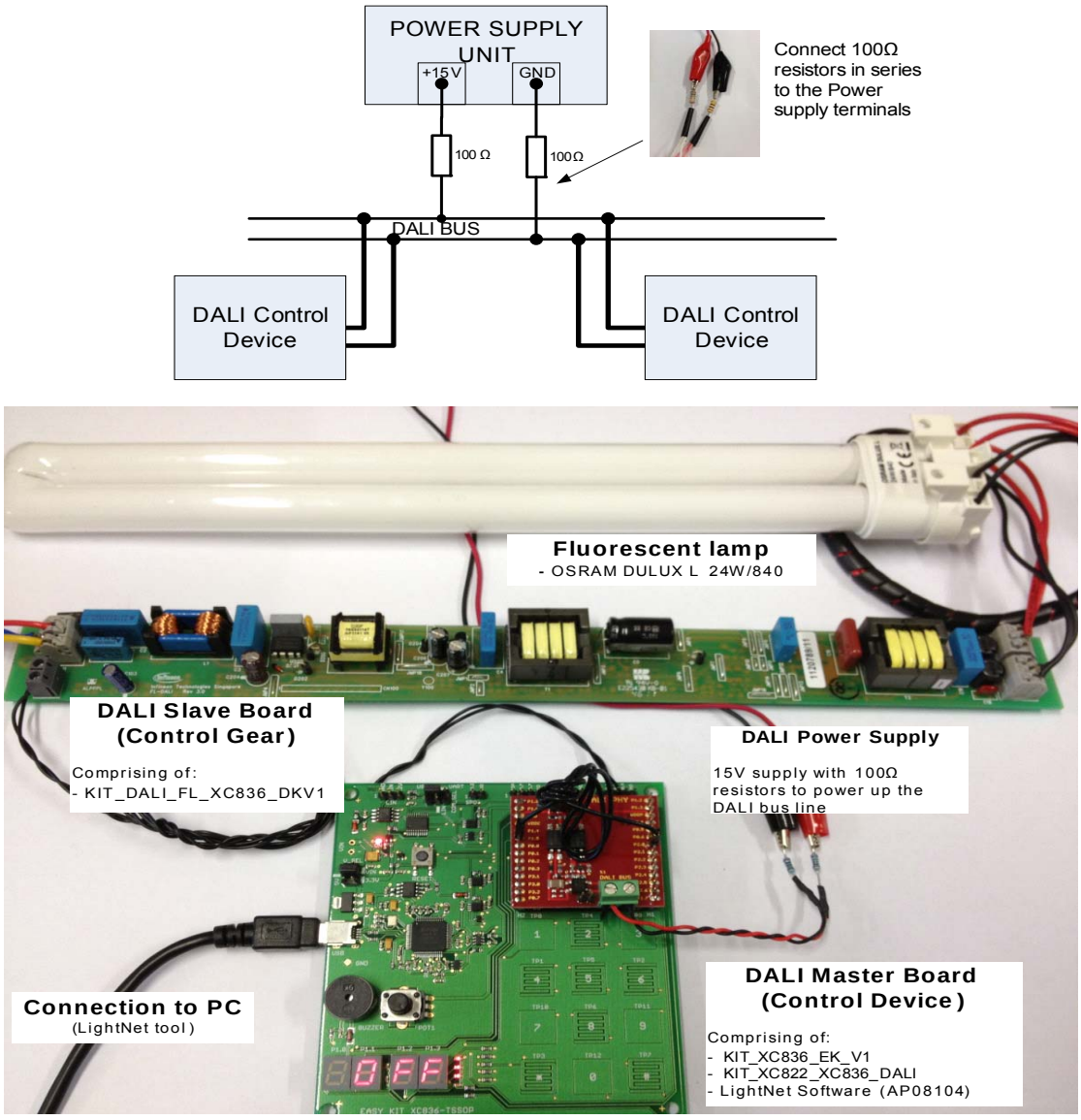


Figure 15 DALI Network Hardware Connection

5 Summary

The example in this document demonstrates the ease of creating a DALI control gear, based on an earlier solution (AN-ICB2FL02G), for dimming and on/off control in any DALI network. This solution demonstrates just some of the flexibility offered by Infineon microcontrollers for creating a wide variety of robust applications.

6 References

[1] IEC 62386 Digital addressable lighting interface; Part 101: General requirements - System (Edition 1.0, 2009-06)

[2] IEC 62386 Digital addressable lighting interface; Part 102: General requirements - Control gear (Edition 1.0, 2009-06)

[3] AN-ICB2FL02G Smart Ballast Control IC for Fluorescent Lamp Ballasts Dimming Demoboard

[4] AP08102 DALI Control Gear Software Stack

[5] AP08104 Guide to using DALI LightNet tool

[6] XC836 User Manual 1.0

APPENDIX - DALI FL Board

Schematic for KIT_DALI_FL_XC836_DKV1

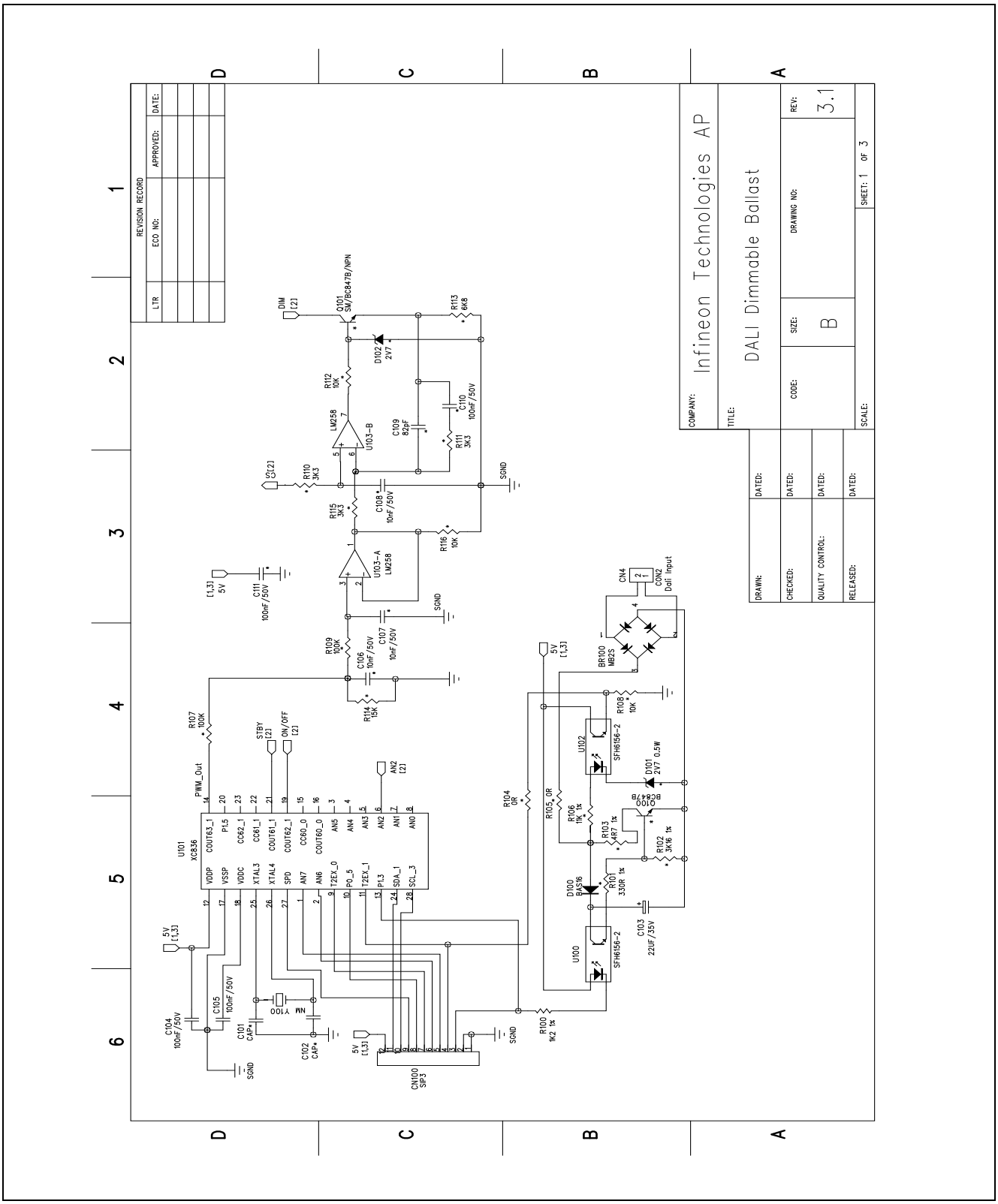


Figure 16 DALI FL Schematic (Part 1of 3)

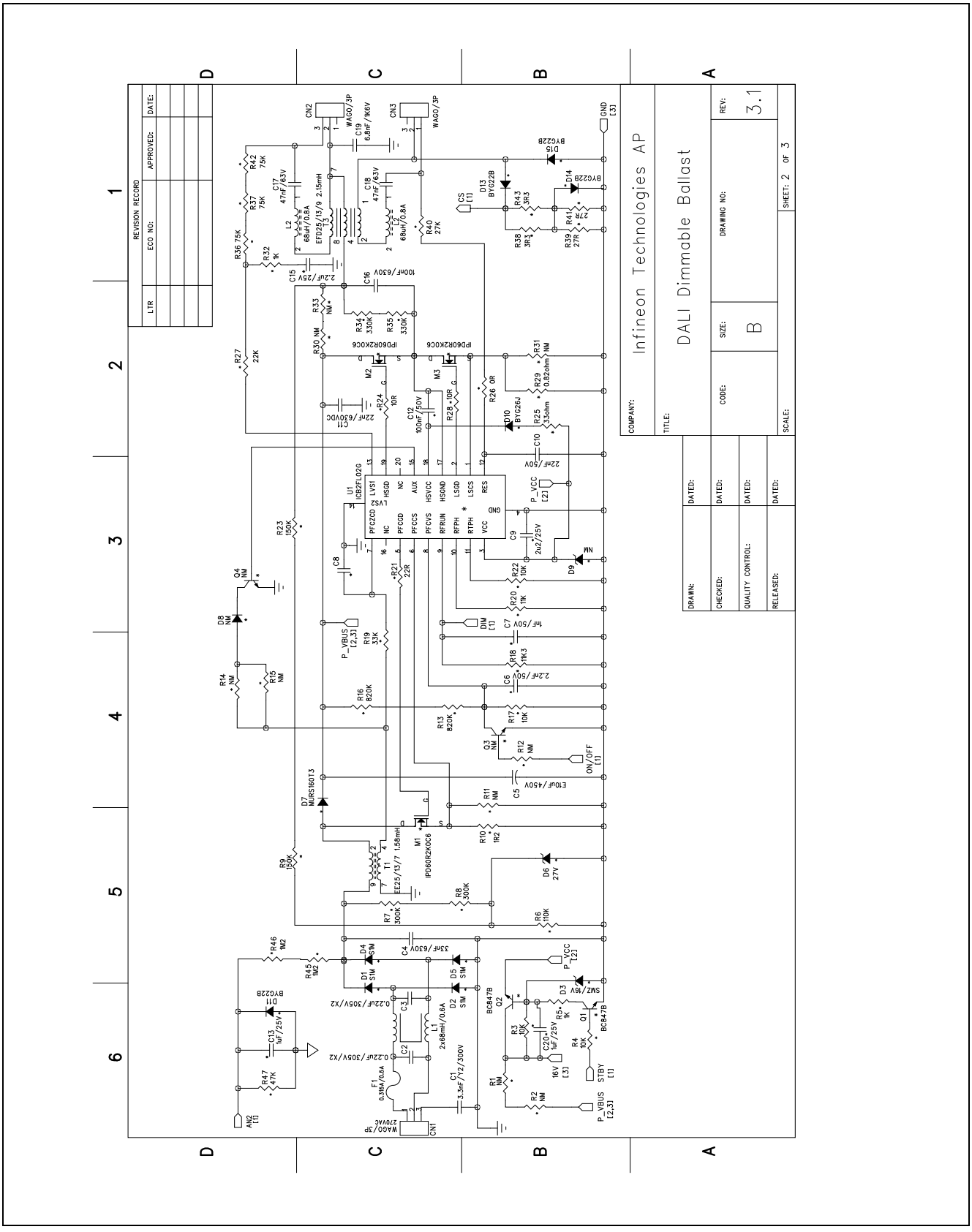


Figure 17 DALI FL Schematic (Part 2 of 3)

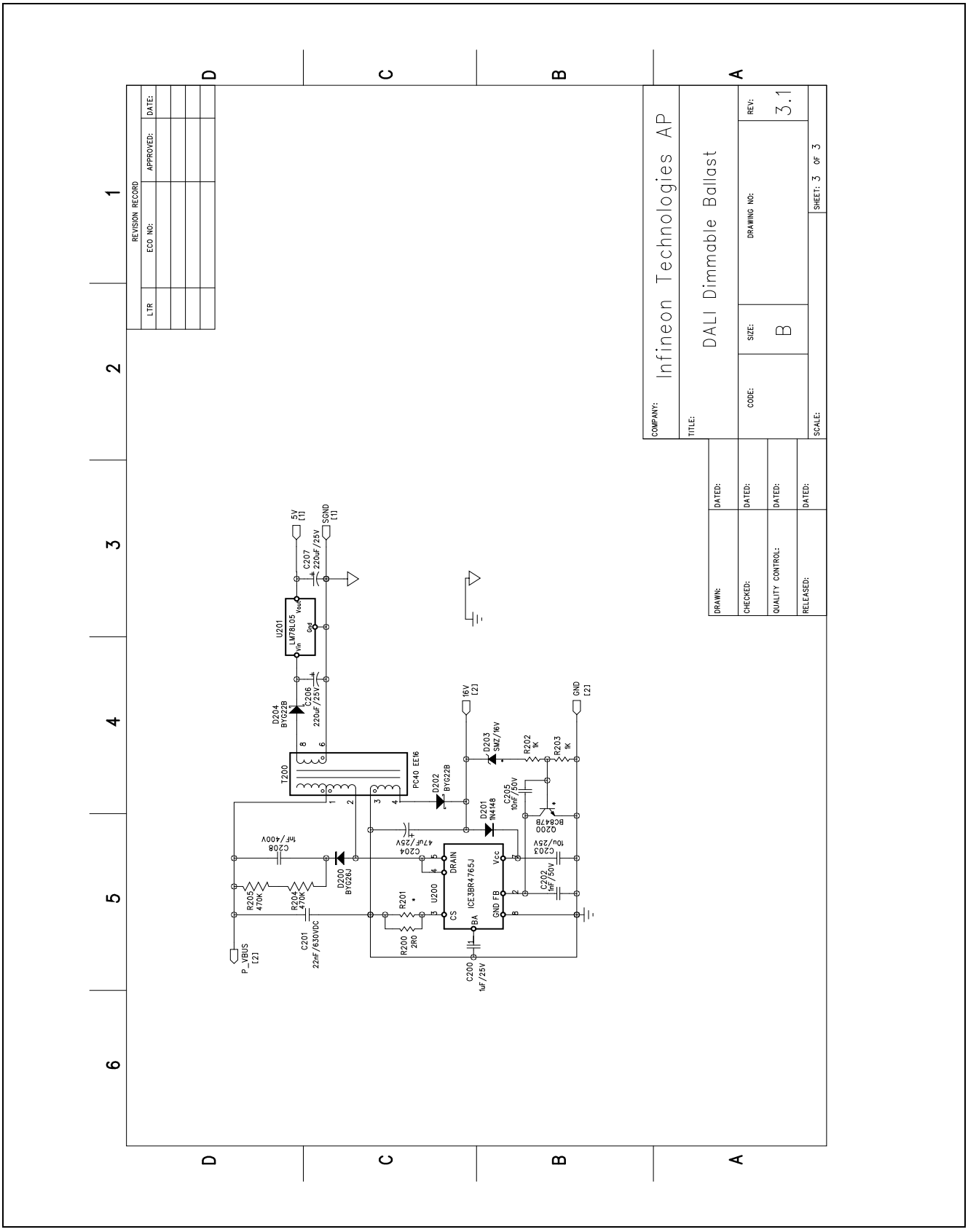


Figure 18 DALI FL Schematic (Part 3 of 3)

APPENDIX - Bill of Material

BOM for KIT_DALI_FL_XC836_DKV1

Item	Ref Des	Description	Package	Qty
1	BR100	MB2S	TO269	1
2	C1	B/3.3nF/Y2/300V		1
3	C2	B/0.22uF/400V/X2	CAP-18L10W15P	1
4	C3	B/0.22uF/400V/X2	CAP-18L10W15P	1
5	C4	B/33nF/630V		1
6	C5	E10uF/450V	CE-12.5D5P	1
7	C6	SMC_0805/2.2nF/50V	0805	1
8	C7	SMC_0805/1nF/50V	1206	1
9	C8	SM/C0805/*	0805	NM
10	C9	SMC_0805/2u2 25V	0805	1
11	C104	SMC_0805/100nF/50V	0805	1
12	C105	SMC_0805/100nF/50V	0805	1
13	C110	SMC_0805/100nF/50V	0805	1
14	C111	SMC_0805/100nF/50V	0805	1
15	C12	SMC_0805/100nF/50V	0805	1
16	C106	SMC_0805/10nF/50V	0805	1
17	C107	SMC_0805/10nF/50V	0805	1
18	C108	SMC_0805/10nF/50V	0805	1
19	C205	SMC_0805/10nF/50V	0805	1
20	C10	SMC_0805/22nF/50V	0805	1
21	C11	B/22nF/630VDC	CAP-12L55W10P	1
22	C201	B/22nF/400VDC	CAP-12L55W7.5P	1
23	C13	B/1uf 25V	0805	1
24	C200	SMC_0805/1uF/25V	0805	1
25	C20	SMC_0805/1uF/25V	0805	1
26	C202	SMC_0805/1nF/25V	0805	1
27	C203	SMC_0805/10uF 25V	0805	1
28	C15	SM/C0805/2.2uF/25V	0805	1
29	C16	B/100nF/630V	CAP-12L55W10P	1
30	C17	B/47nF/63V	CAP-8L35W5P	1
31	C18	B/47nF/63V	CAP-8L35W5P	1
32	C19	B/6.8nF/1K6V	CAP-18L55W15P	1
33	C208	1nF/1000V		1
34	CN100	SIP3	SIP-12P	NM
35	C101	CAP *	0805	NM
36	C102	CAP *	0805	NM
37	C103	22UF/35V	CE-5D3P	1
38	C109	SM/C0805/82pF	0805	1
39	C204	47uf 25V	CE-8D5P	1
40	C206	220uF/25V	CE-8D5P	1

Figure 19 BOM (Part 1 of 4)

Item	Ref Des	Description	Package	Qty
41	C207	220uF/25V	CE-8D5P	1
42	CN1	WAGO/3P	CON-3P	1
43	CN2	WAGO/3P	CON-3P	1
44	CN3	WAGO/3P	CON-3P	1
45	CN4	CON2	CON-3P	1
46	D1	S1M	SMB	1
47	D2	S1M	SMB	1
48	D4	S1M	SMB	1
49	D5	S1M	SMB	1
50	D3	SMZ/16V	SOD80C	1
51	D9	SMZ/16V	SOD80C	NM
52	D203	SMZ/16V	SOD80C	1
53	D6	SMZ/27V*	SOD80C	1
54	D102	SMZ2V7	SOD80C	1
55	D7	MURS160T3	SMB	1
56	D8	STTH1R06A	SMA	NM
57	D10	STTH1R06RL	DO-41	1
58	D200	STTH1R06RL	DO-41	1
59	D11	SM/BYG22B	SMA	1
60	D13	SM/BYG22B	SMA	1
61	D14	SM/BYG22B	SMA	1
62	D15	SM/BYG22B	SMA	1
63	D12	SM/BYG22A	SMA	NM
64	D204	MUR120R	SMA	1
65	D202	MUR120R	SMA	1
66	D100	LL5819	MINIMELF	1
67	D101	BZX284C 2V7 0.5W	SOD80C	1
68	D201	1N4148	SOD80C	1
69	F1	MST 500MA 250V	D835W43P508	1
70	J100	CON2	SIP-2P-156	NM
71	L1	2x68mH/0.6A	DE20	1
72	LF1	Drum Core/68uH/0.8A	L-8D5P	1
73	LF2	Drum Core/68uH/0.8A	L-8D5P	1
74	M1	IPD60R2K0C6	DPAK	1
75	M2	IPD60R2K0C6	DPAK	1
76	M3	IPD60R2K0C6	DPAK	1
77	Q1	SM/BC847B/NPN	SOT23	1
78	Q2	SM/BC847B/NPN	SOT23	1
79	Q100	SM/BC847B/NPN	SOT23	1
80	Q101	SM/BC847B/NPN	SOT23	1

Figure 20 BOM (Part 2of 4)

Item	Ref Des	Description	Package	Qty
81	Q200	SM/BC847B/NPN	SOT23	1
82	Q3	SM/BC847B/NPN	SOT23	NM
83	Q4	BCP55/NPN/SOT223 *	SOT223	NM
84	R1	SMR_1206/470K	1206	NM
85	R2	SMR_1206/470K	1206	NM
86	R3	SMR_0805/10K	0805	1
87	R17	SMR_0805/10K	0805	1
88	R112	SMR_0805/10K	0805	1
89	R4	SMR_0805/10K	1206	1
90	R22	SMR_0805/10K	1206	1
91	R108	SMR_0805/10K	1206	1
92	R12	SMR_0805/10K	1206	NM
93	R107	SMR_0805/100K	1206	1
94	R109	SMR_0805/100K	1206	1
95	R5	SMR_0805/1K	1206	1
96	R202	SMR_0805/1K	0805	1
97	R203	SMR_0805/1K	0805	1
98	R6	SMR_1206/110K	1206	1
99	R7	SMR_1206/300K	1206	1
100	R8	SMR_1206/300K	1206	1
101	R9	SM1206/150K	1206	1
102	R23	SM1206/150K	1206	1
103	R36	SMR_1206/75K	1206	1
104	R37	SMR_1206/75K	1206	1
105	R42	SMR_1206/75K	1206	1
106	R10	SMR_1206/1R2	1206	1
107	R11	SMR_1206/*	1206	NM
108	R13	SMR_1206/820K	1206	1
109	R16	SMR_1206/820K	1206	1
110	R14	SMR_1206/390*	1206	NM
111	R15	SMR_1206/390*	1206	NM
112	R18	SMR_0805/11K3	1206	1
113	R19	SMR_1206/33K	1206	1
114	R20	SMR_0805/11K	0805	1
115	R106	SMR_0805/11K 1%	1206	1
116	R21	SMR_0805/22R	0805	1
117	R24	SMR_0805/10R	1206	1
118	R25	SM1206/33ohm	1206	1
119	R27	SMR_1206/22K	1206	1
120	R28	SMR_0805/10R	0805	1

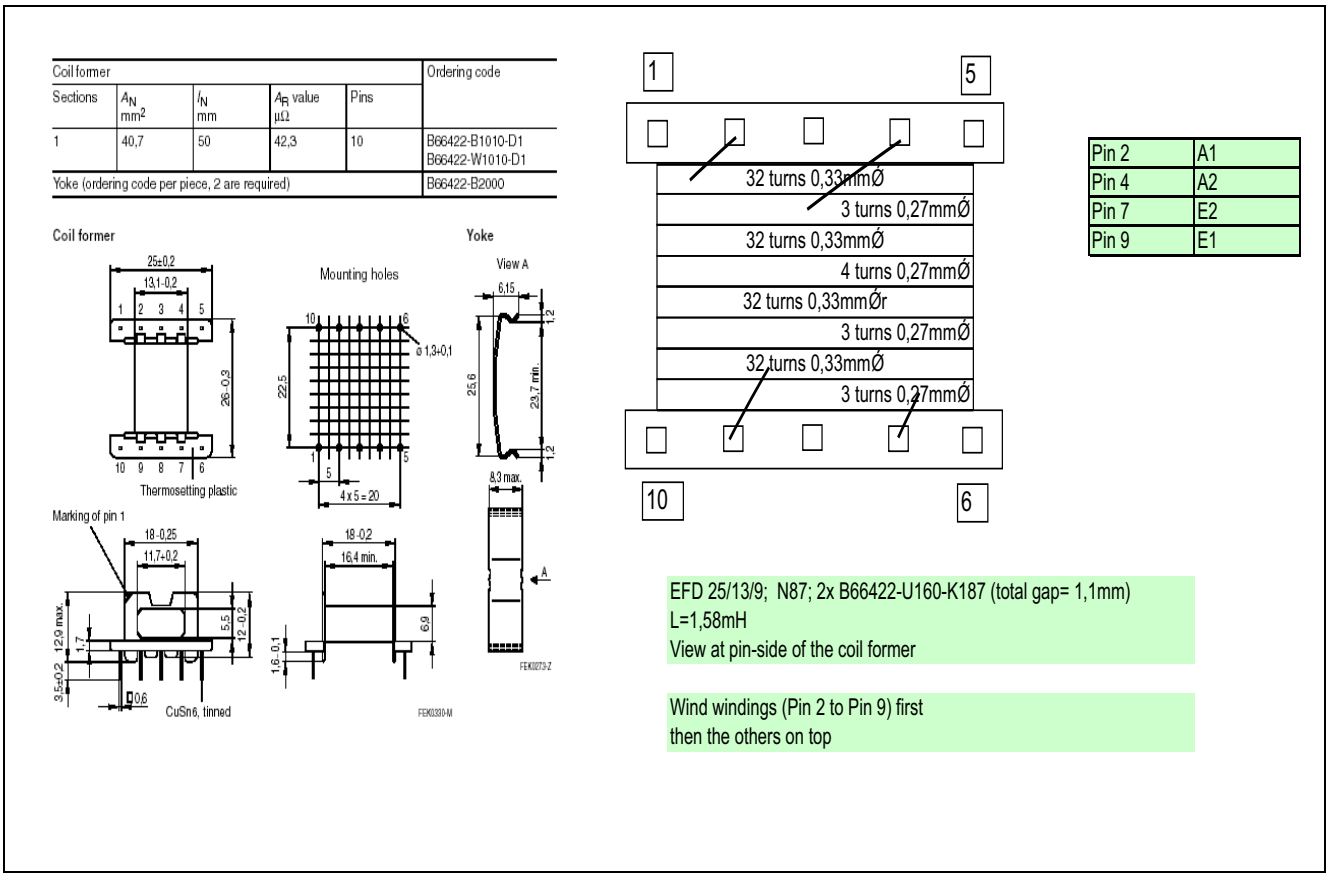
Figure 21 BOM (Part 3of 4)

Item	Ref Des	Description	Package	Qty
121	R29	SM1206/0.82ohm	1206	1
122	R30	SM1206/*	1206	NM
123	R31	SM1206/*	1206	NM
124	R32	SMR_1206/1K	1206	1
125	R33	SM1206/*	1206	NM
126	R34	SMR_1206/330K	1206	1
127	R35	SMR_1206/330K	1206	1
128	R38	SM1206/3R3	1206	1
129	R43	SM1206/3R3	1206	1
130	R39	SM1206/27R	1206	1
131	R41	SM1206/27R	1206	1
132	R40	SM1206/27K	1206	1
133	R204	470k/0.5W	1206	1
134	R205	470k/0.5W	1206	1
135	R100	1K2 1%	1206	1
136	R101	SMR_0805/330R 1%	0805	1
137	R102	SMR_0805/3K16 1%	0805	1
138	R103	SMR_0805/4R7 1%	0805	1
139	R104	SMR_0805/0R	1206	1
140	R26	SMR_1206/0R	1206	1
141	R105	SMR_1206/0R	1206	1
142	R110	SMR_0805/3.3K	1206	1
143	R111	SMR_0805/3.3K	0805	1
144	R113	SMR_0805/6.8K	0805	1
145	R114	SMR_0805/15K	0805	1
146	R115	SMR_0805/3K3	0805	1
147	R116	SMR_0805/10K	0805	NM
148	R200	SMR_0805/2R0	0805	1
149	R201	SMR_0805/	0805	NM
150	R45	SMR_0805/1M2	1206	1
151	R46	SMR_0805/1M2	1206	1
152	R47	SMR_0805/47k	0805	1
153	T1	EE25/13/7 1.58mH	EFD25	1
154	T3	EFD25/13/9 2.15mH	EFD25	1
155	T200	PC40 EE16 1.5mH	EE16-5P	1
156	U1	ICB2FL02G (Infineon)	SO20M2	1
157	U100	SFH6156-2	SFH6156	1
158	U102	SFH6156-2	SFH6156	1
159	U101	XC836	TSSOP-28	1
160	U103	LM258	SO8	1
161	U200	ICE3BR4765J (Infineon)	DIP8	1
162	U201	LM78L05	TO-92	1
163	Y100	37.768KHZ Crystal		NM

Figure 22 BOM (Part 4of 4)

APPENDIX - Transformer Drawing

Transformer Drawing: T1, T3, T200



Coil former					Ordering code
Sections	A_N mm²	l_N mm	A_R value µΩ	Pins	
1	40,7	50	42,3	10	B66422-B1010-D1 B66422-W1010-D1
Yoke (ordering code per piece, 2 are required)					B66422-B2000

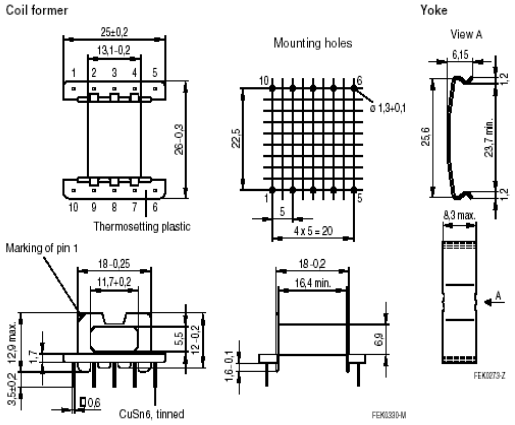
Pin 2	A1
Pin 4	A2
Pin 7	E2
Pin 9	E1

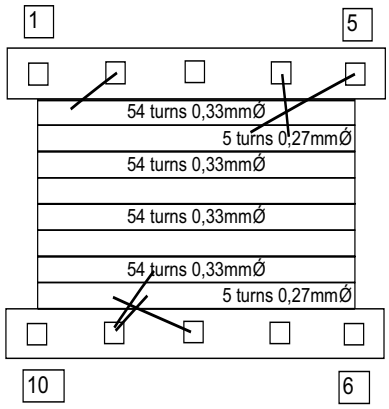
EFD 25/13/9; N87; 2x B66422-U160-K187 (total gap= 1,1mm)
L=1,58mH
View at pin-side of the coil former

Wind windings (Pin 2 to Pin 9) first
then the others on top

Figure 23 Transformer T1

Coil former					Ordering code
Sections	A_N mm²	l_N mm	A_R value µΩ	Pins	
1	40,7	50	42,3	10	B66422-B1010-D1 B66422-W1010-D1
Yoke (ordering code per piece, 2 are required)					B66422-B2000





Pin 2	A1
Pin 4	E2
Pin 5	A2
Pin 8	A3
Pin 9	E1/E3

EFD 25/13/9; N87; 2x B66422-xx-K187 (total gap= 3,0mm)
L=2,15mH
View at pin-side of the coil former

Wind windings (Pin 2 to Pin 9) first
then the others for preheating on top

Figure 24 Transformer T3

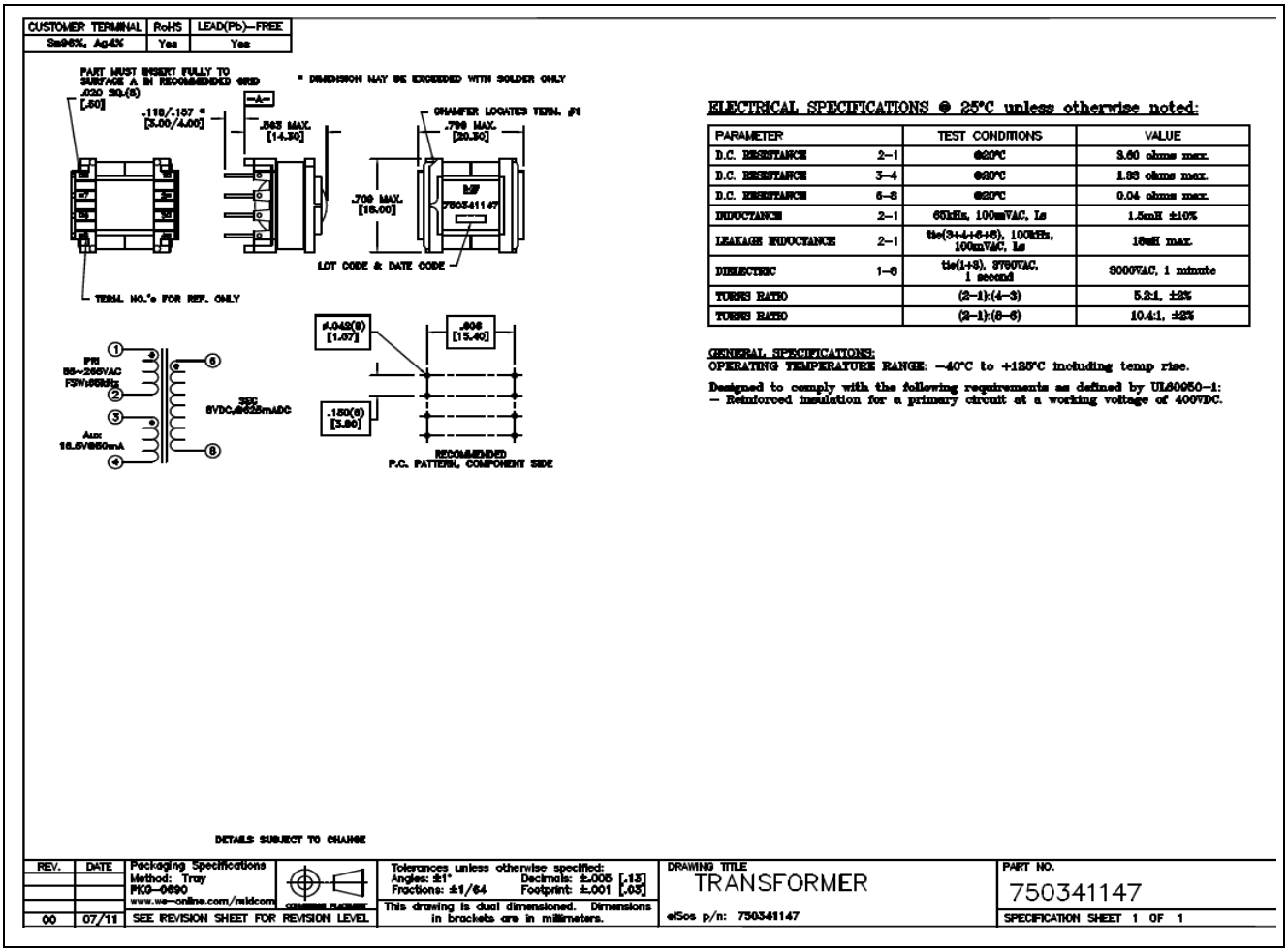


Figure 25 Transformer T200

w w w . i n f i n e o n . c o m

Published by Infineon Technologies AG

AP08134