NXP Semiconductors
User's Guide

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NXP Reference Design Board KW01-RCD-RD

1. Introduction

This manual describes NXP's KW01 RC Dimmer reference design platform.
The KW01-RCD-RD development platform is a reference design intended to operate in a IEEE 802.15.4 network as an end node device. The KW01-RCD-RD board contains the MKW01Z128 development platform is a highly integrated, cost-effective, system-in-package (SIP), sub-1 GHz wireless node solution transceiver and low-power ARM® Cortex® M0+ CPU microcontroller.

Contents

2. KW01-RCD-RD Board Overview and Description

The KW01-RCD-RD is a custom battery powered reference design board which is intended to operate in a IEEE 802.15.4 network as an end node device.

The KW01 RC Dimmer reference design board is based on the NXP MKW01Z128 device.

The MKW01Z128 is targeted for the following low-power wireless applications:

- Automated Meter Reading
- Wireless Sensor Networks
- Home and Building Automation
- Wireless Alarm and Security Systems
- Industrial Monitoring and Control

The Sub-GHz RC Dimmer reference design demonstrates the MKW01Z128 working in a home automation application.

The MKW01Z128 transceiver is a single-chip integrated circuit ideally suited for high performance ISM band RF applications. It is intended for use as a high-performance, low-cost FSK and OOK RF transceiver for robust, frequency agile, half-duplex bi-directional RF links. The MKW01Z128CHN is intended for applications over a wide frequency range, including the 433 MHz and 868 MHz European and the 902–928 MHz North American ISM bands.

NXP supplements the MKW01Z128 with tools and software that include hardware evaluation and development boards, software development IDE and applications, drivers, custom PHY usable with NXP's IEEE 802.15.4 compatible MAC, and SMAC solutions on the KW01 section of the NXP website.

2.1 KW01-RCD-RD board features

The KW01-RCD-RD board contains the MKW01Z128 device and demonstrates some of the available features in a custom form factor board. With a specific application and taking advantage of the MCU low power capabilities powered by a 3.7 V Li-Ion rechargeable battery, with a 32 MHz reference crystal oscillator crystal (Y1), minimum RF circuitry including antenna and supporting minimum circuitry in a custom form factor to operate in the 915 MHz or 868 MHz frequency bands.

The following figure shows the KW01-RCD-RD board.

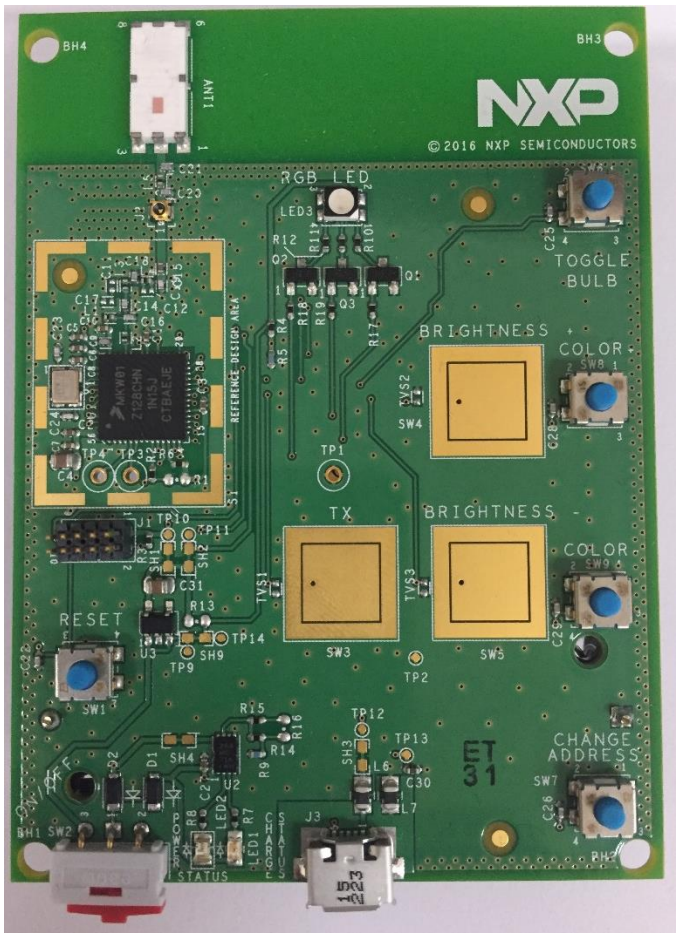

Figure 1. KW01-RCD-RD

The KW01 RC Dimmer development board includes the following features:

- Based on NXP's low-cost MKW01Z128 sub-1 GHz wireless node solution with an FSK, GFSK, MSK, or OOK modulation-capable transceiver and low-power ARM Cortex M0+CPU microcontroller, and a functional set of MCU peripherals into a 60-pin LGA package
- Reference design area with small footprint, low-cost RF node
  - Unbalanced input/output port
  - Flexible RF-Front End for different bands operation
  - Programmable output power from -18 dBm to +13 dBm in 1 dB steps (RFIO output).
- Integrated dual band chip antenna for 800 MHz and 900 MHz ISM bands.
- Micro-miniature coaxial connector (MMCX) for conducted RF measurements.
- SWD debug port
- 32 MHz reference oscillator
- 4 application push buttons
- 3 application TSI electrodes (touch buttons)
- Application RGB LED
- Li-Ion battery charger based on NXP's MC34671

- Green LED indicator connected to battery charger
- Red LED indicator connected to battery charger
- Micro AB USB port which feeds battery charger

The following figure shows the main board features for the NXP KW01-RCD-RD board.

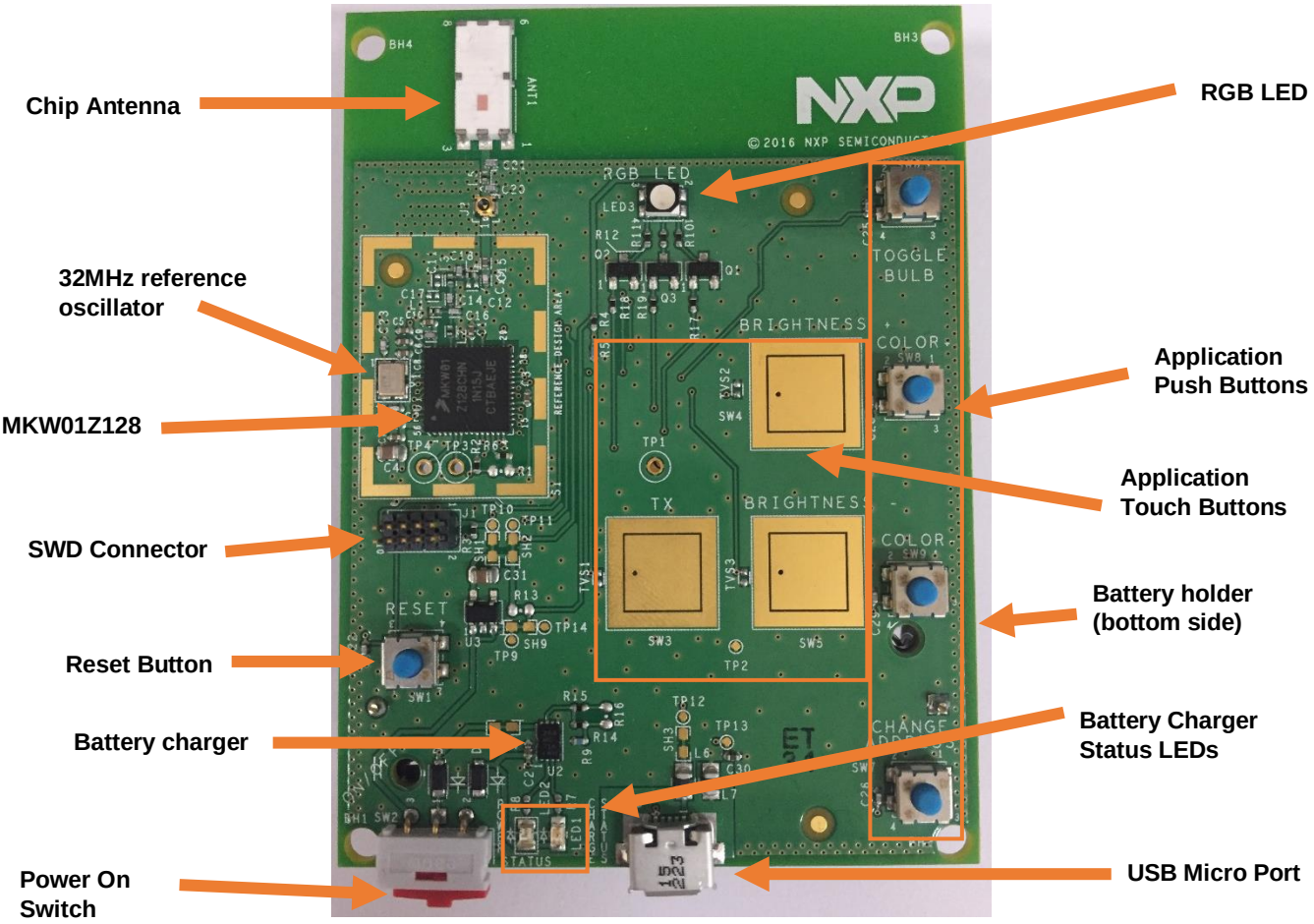

Figure 2. KW01-RCD-RD components

3. KW01-RCD-RD Development Platform

3.1 KW01-RCD-RD board features

The KW01-RCD-RD development platform is a reference design and is based on the NXP MKW01Z128 MCU. The device leverages a 32 MHz reference oscillator crystal, RF circuitry including an integrated chip antenna (and supporting circuitry), in a small form factor battery-operated board.

The following figure shows a simple block diagram.

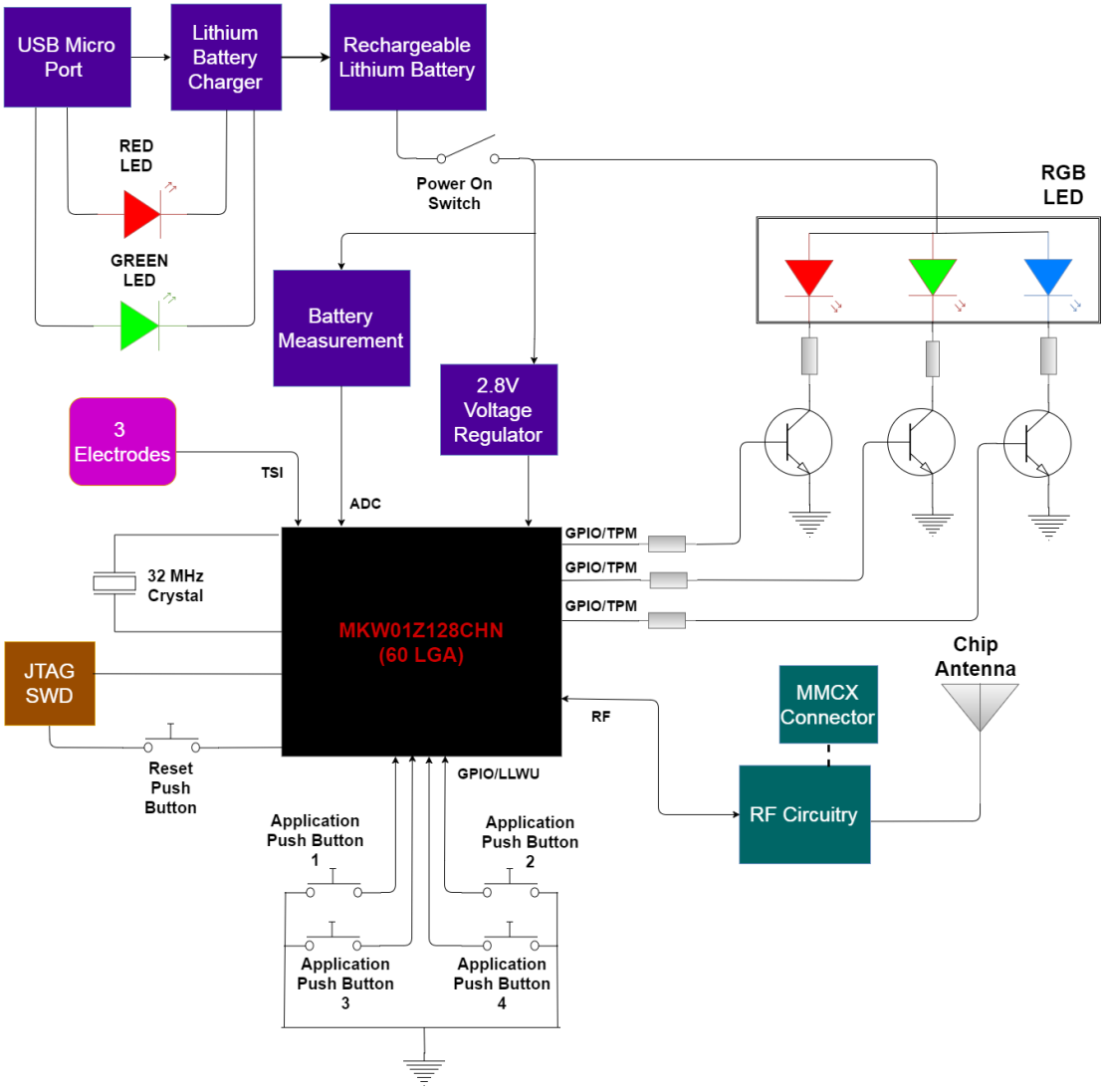

Figure 3. KW01-RCD-RD block diagram

3.2 Board and MCU specifications

Table 1. KW01-RCD-RD specifications

Parameter	Min	Typ	Max	Units	Notes/Conditions
General					
Size (PCB: X, Y)	—	—	5.969 x 8.128 2.350 x 3.200	cm inches	—
Layer build (PCB)	—	1.57 0.062	—	mm inches	2-Layer
Dielectric material (PCB)	—	—	—	—	FR4
Power					
Current consumption	—	—	—	mA	Varies with operational mode. Refer to data sheet.
Temperature					
Operating temperature (see note)	-40	+25	+70	°C	Operating temperature is limited to +70 °C due to switches. The basic circuit is good for a maximum temperature of +85 °C
Storage temperature	-30	+25	+70	°C	—
RF Receiver					
FSK Sensitivity	—	-105 to -120	—	dBm	—
OOK Sensitivity	—	-112	—	dBm	—
Adjacent channel rejection (offset = ±25KHz or 50KHz)	—	-42	—	dB	—
2nd order intercept point	—	+75	—	dBm	—
3rd order intercept point		+20		dBm	—
RSSI dynamic range	-115	—	0	—	—
RF Transmitter					
RF Power Output (RFIO pin)	-18	—	+13	dBm	Programmable in 1dB steps.
Frequency range	290 424 862	To To To	340 510 1020	MHz MHz MHz	MCU supported, board requires to be reworked for bands operation. Programmable.

3.3 RF performance and considerations

KW01-RCD-RD board includes RF matching network and an integrated dual band chip antenna (ANT1) to operate in 800 MHz and 900 MHz bands; It also includes a MMCX connector (J2) for measurement purposes.

The KW01-RCD-RD board delivers -18 to +13 dBm programmable output power using RFIO output option – No PA_BOOST output connection –.

The following figure shows the typical topology for the RF circuitry.

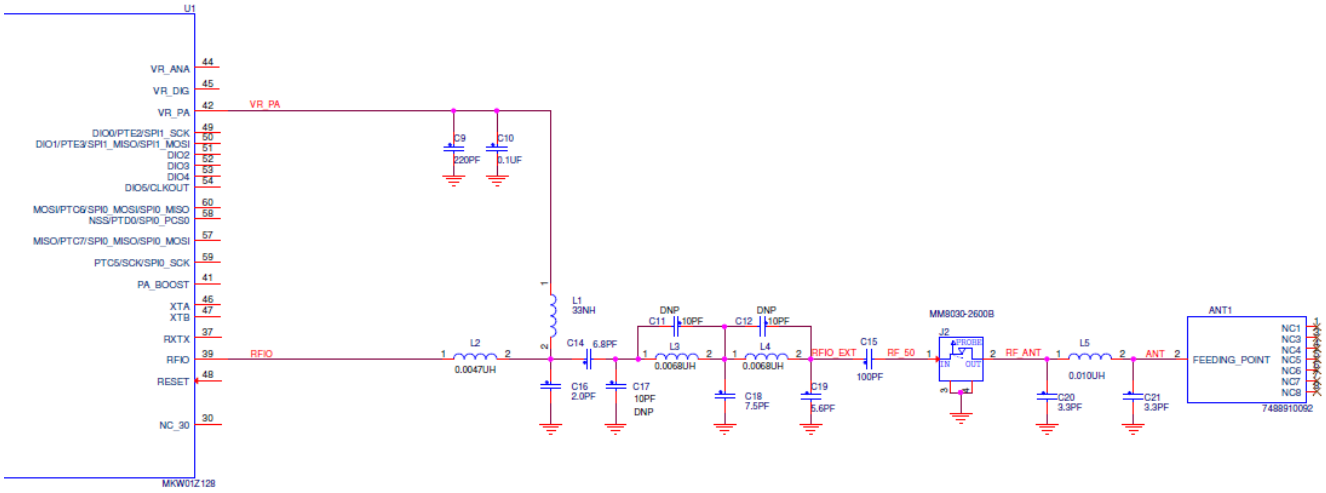

Figure 4. KW01-RCD-RD RF circuitry

NOTE

RF matching network can be changed to operate in other frequencies.

3.4 Clocks

The KW01-RCD-RD provides one clock:

- 32 MHz Reference Oscillator: Figure 5 shows the external 32 MHz external crystal Y1. This mounted crystal must meet the MKW01Z128 specifications.
  - Capacitors C23 and C24 provide the bulk of the crystal load capacitance. At 25 °C it is desired to have the frequency accurate to ±10 ppm or less to allow for temperature variation.
  - Signal DIO5/CLKOUT is used to supply an external clock to MCU die and to measure the 32 MHz oscillator frequency.

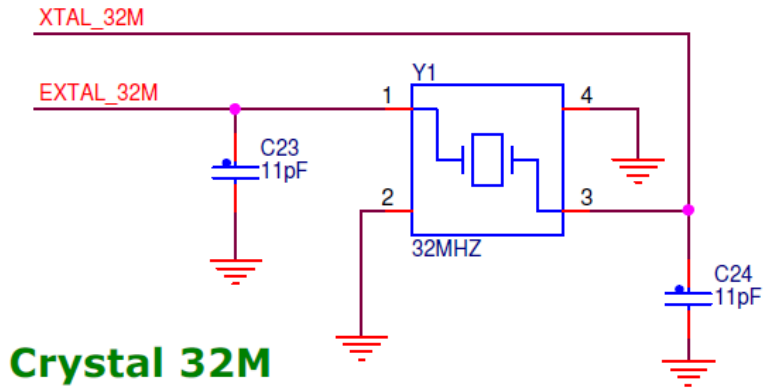

Figure 5. KW01-RCD-RD 32 MHz reference oscillator circuit

3.5 Power management

The KW01-RCD-RD board can be powered by two different options, a single battery operation, and USB cable powered.

For a single battery operation, the board uses a 3.7 V 1200 mA rechargeable battery (BT1) which is charged by the NXP MC34671AEP Li-Ion battery charger (U2).

KW01-RCD-RD includes a 2.8 V voltage regulator, which feeds the MKW01Z128. The KW01-RCD-RD power management circuit is shown in the following figure.

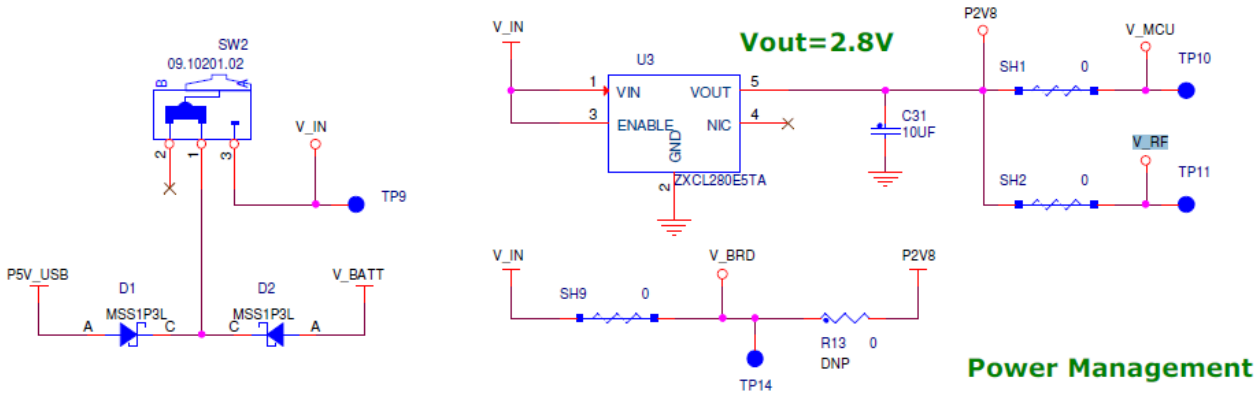

Figure 6. KW01-RCD-RD power management circuit

3.6 Battery charger

The NXP MC34671AEP Li-Ion battery charger is fed through the USB micro port (J3), intended to be used for powering only -No USB communication-.

KW01-RCD-RD battery charger circuit is shown in the following figure and the USB port circuit is shown in Figure 8.

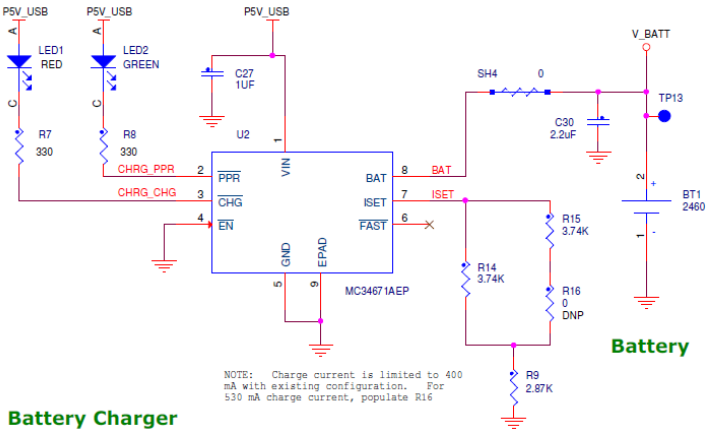

Figure 7. KW01-RCD-RD battery charger circuit

NOTE

The NXP MC34671AEP Li-Ion battery charger provides 400 mA with default configuration but for a faster charge R6 can be populated to obtain 530 mA (this charge is not commonly supported by PC's USB port).

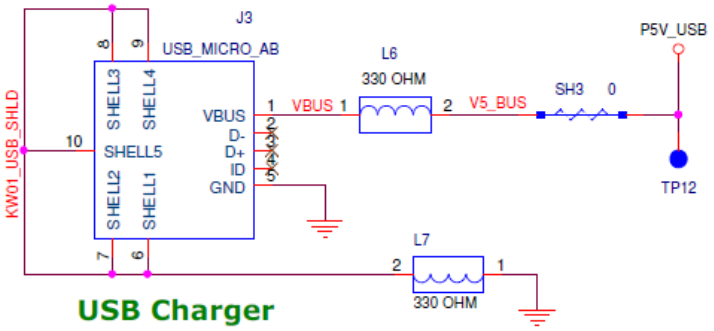

Figure 8. KW01-RCD-RD USB port circuit.

The Li-Ion battery charger has a green LED (LED2) indicator connected to NXP MC34671AEP which turns on to indicate input power presence. As well it has a second indicator that turns on red to indicate when charge is completed labeled as LED1.

3.6.1 Battery measurement

A circuit is provided in order to take battery measurements. Battery voltage is connected to an ADC pin in MKW01Z128. The circuit is shown in the following figure.

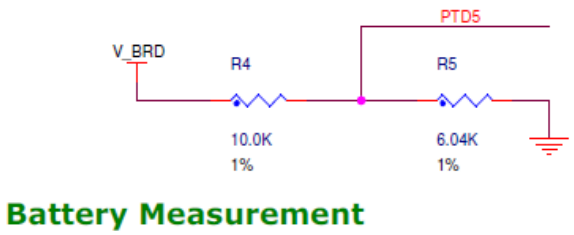

Figure 9. Battery measurement circuit

3.7 Debugger / SWD Connector

The 10-pin SWD 2x5 header J1 is provided to connect the MKW01Z128 serial debug port to a standard Kinetis Series debug module.

The SWD port connector is shown in the following figure.

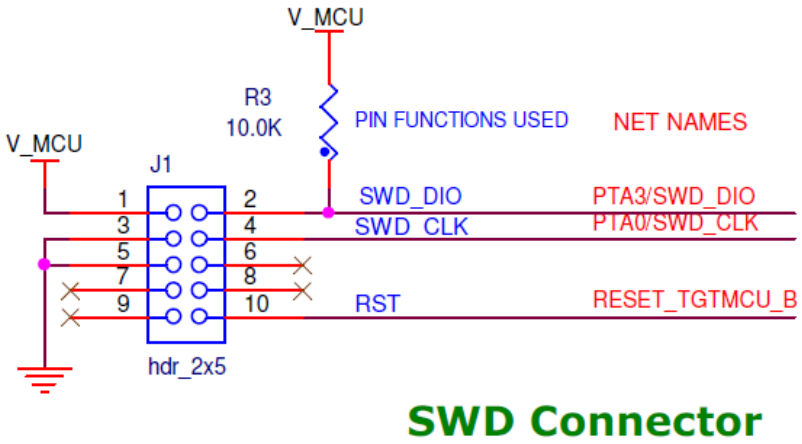

Figure 10. KW01-RCD-RD SWD Connector

3.8 Application buttons

The KW01-RCD-RD board contains 4 application push buttons connected to MKW01Z128's LLWU pins and 3 electrodes connected to MKW01Z128's TSI pins which simulates application touch buttons.

The following table shows buttons and connections.

Table 2. Application buttons

Reference designator	Button type	Connection
SW3	Touch button (electrode)	PTB17/TSI0_CH10
SW4	Touch button (electrode)	PTB0/ TSI0_CH0
SW5	Touch button (electrode)	PTB2/ TSI0_CH7
SW6	Push button	PTC4/LLWU_P8
SW7	Push button	PTC1/ LLWU_P6
SW8	Push button	PTD6/ LLWU_P15
SW9	Push button	PTD4/ LLWU_P14

3.8.1 Push buttons

The KW01-RCD-RD board contains four application push buttons connected to MKW01Z128's LLWU pins. The following figure shows the application push buttons circuits.

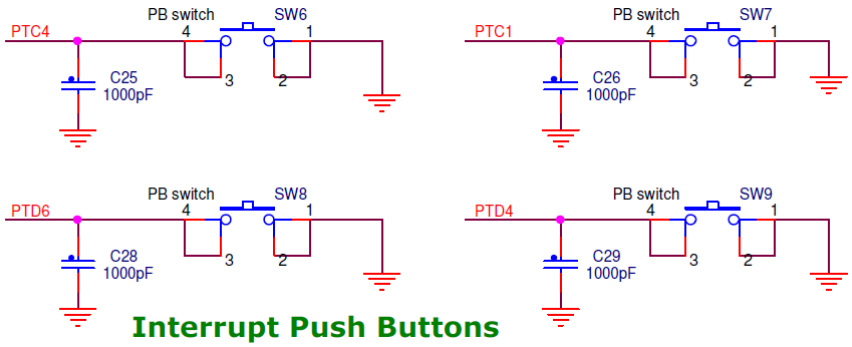

Figure 11. Application push buttons

3.8.2 Electrodes

The KW01-RCD-RD board contains three electrodes which simulates touch buttons dedicated for application purposes. Electrodes are connected to MKW01Z128's TSI pins. The following figure shows the electrode's circuit.

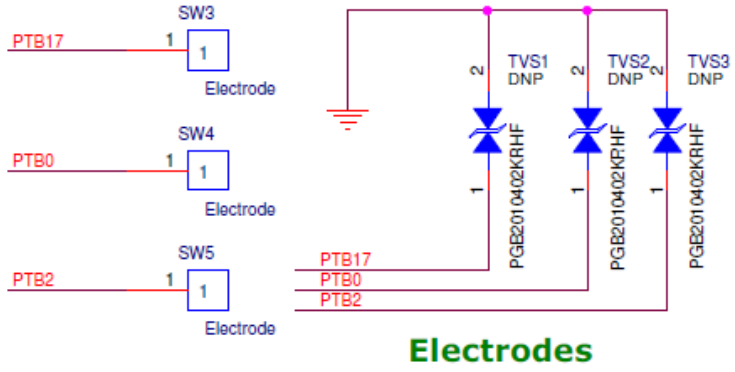

Figure 12. Application push buttons

3.9 RGB LED

The KW01-RCD-RD board contains an application RGB LED (LED3). Set a logic 1 in the desired pin to turn it on. The following figure shows the RGB LED circuit.

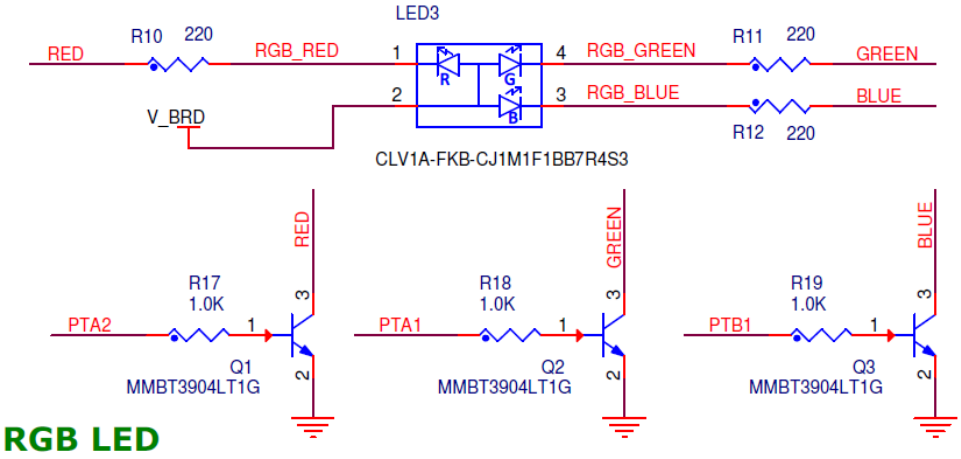

Figure 13. Application RGB LED

3.10 Schematic, board layout and bill of material

3.10.1 Schematic

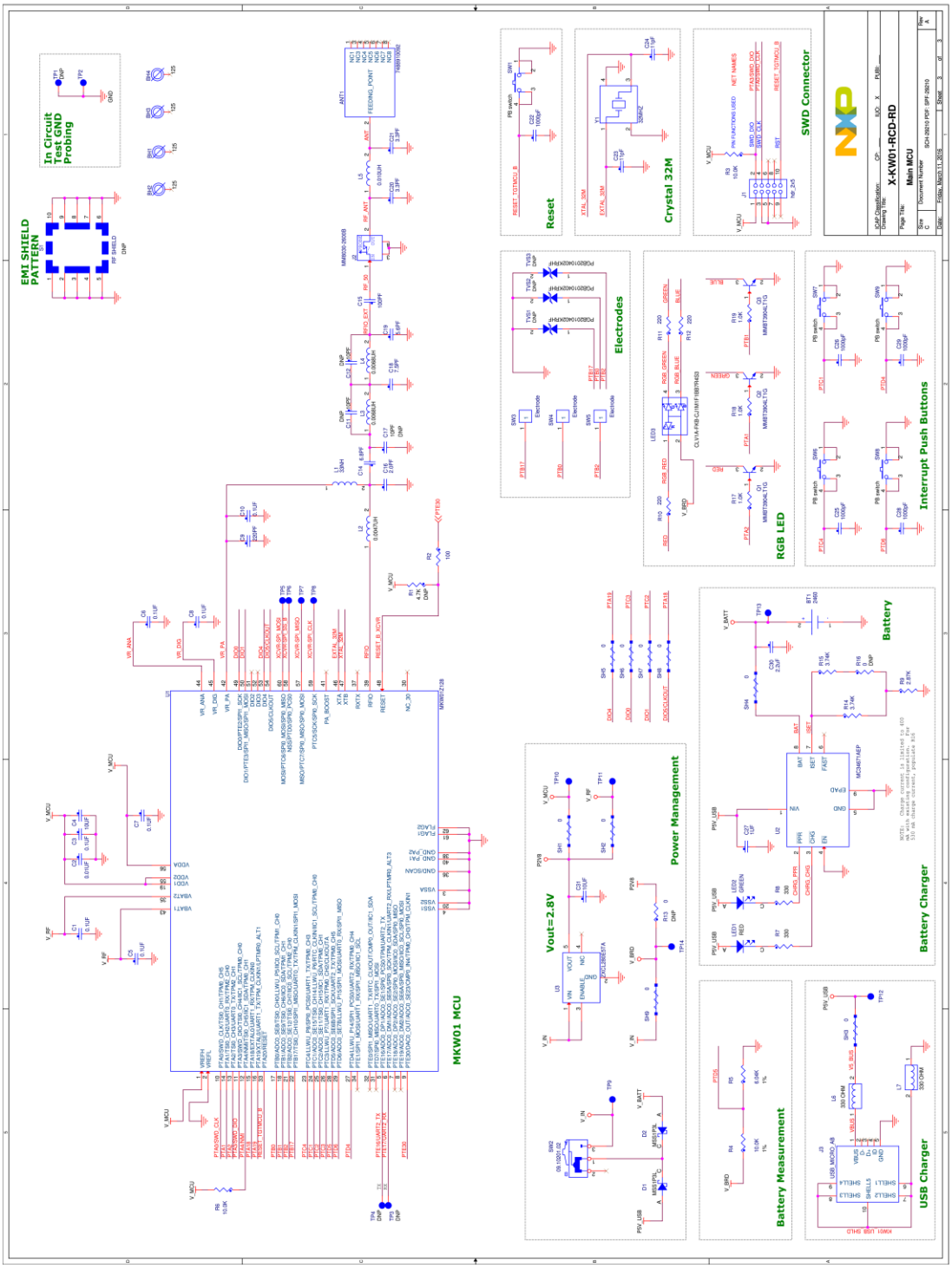

Figure 14. KW01-RCD-RD schematic rev. A.

3.10.2 Board Layout

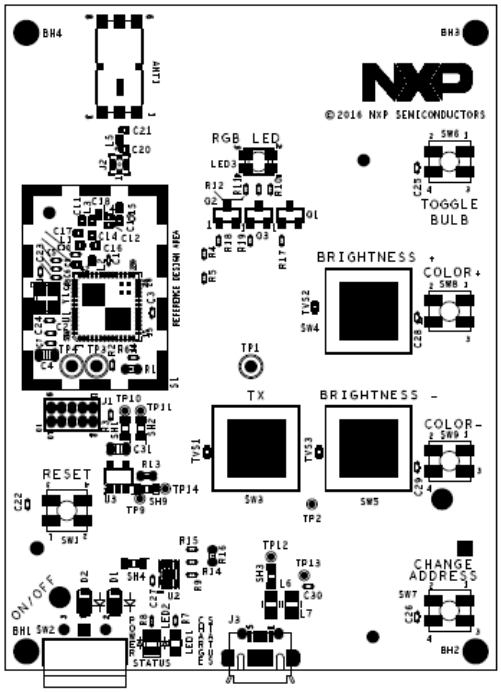

Figure 15. KW01-RCD-RD reference board component location (top view)

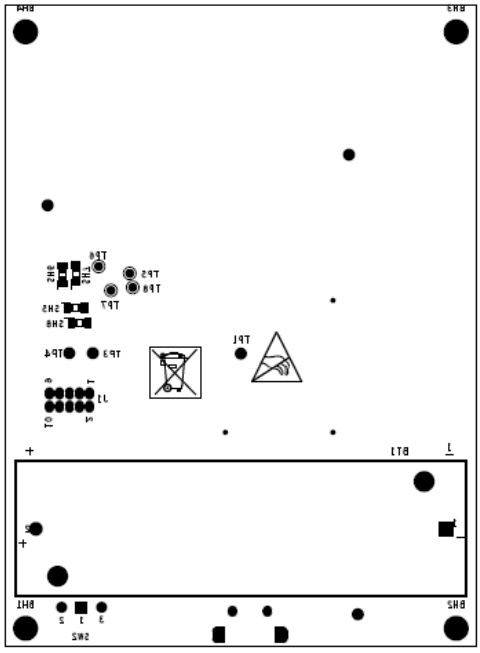

Figure 16. KW01-RCD-RD reference board component location (top view)

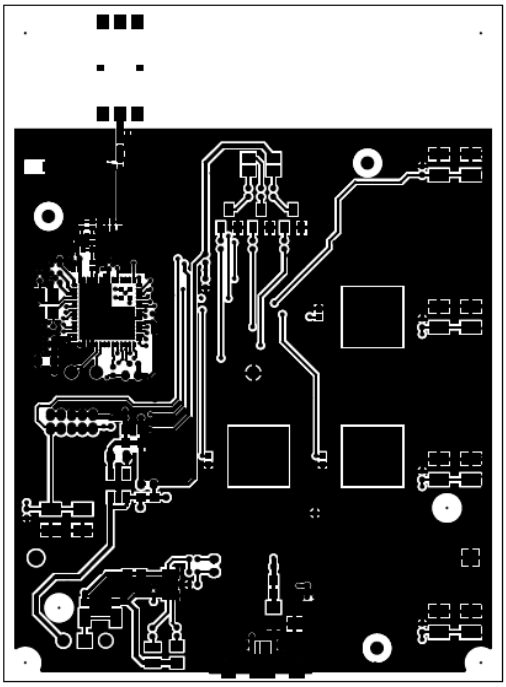

Figure 17. KW01-RCD-RD reference board layout (top view)

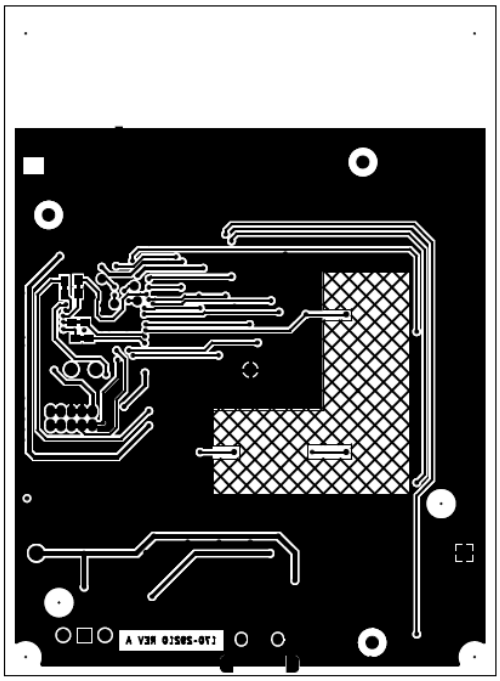

Figure 18. KW01-RCD-RD reference board layout (bottom view)

3.11 Board Layout

Table 1. Bill of materials

Item	Qty	Reference	Value	Description	Mfg. Name	Mfg. Part Number
1	1	ANT1	7488910092	ANTENNA 868TO960MHZ SMT 50 OHM WE-MCA CHIP	WURTH ELEKTRONIK EISOS GMBH & CO. KG	7488910092
2	4	BH1, BH2, BH3, BH4	125	NON-PLATED MOUNTING HOLE 125 DRILL / 160 KEEPOUT NO PART TO ORDER	NA	NA
3	1	BT1	2460	BATTERY HOLDER AA 2460 TH	KEYSTONE ELECTRONICS	2460
4	7	C1, C3, C5, C6, C7, C8, C10	0.1UF	CAP CER 0.1UF 16V 10% X7R 0402	KEMET	C0402C104K4RAC
5	1	C2	0.01UF	CAP CER 0.01UF 50V 10% X7R 0402	WALSIN TECHNOLOGY CORP.	0402B103K500CT
6	2	C4, C31	10UF	CAP CER 10UF 10V 10% X5R 0805	MURATA	GRM21BR61A106KE19_
7	1	C9	220PF	CAP CER 220PF 50V 5% C0G 0402	KEMET	C0402C221J5GAC
8	3	C11, C12, C17 **DNP**	10PF	CAP CER 10PF 50V 5% C0G 0402	AVX	04025A100JAT2A
9	1	C14	6.8PF	CAP CER 6.8PF 50V 0.5PF C0G 0402	MURATA	GRM1555C1H6R8DZ01J
10	1	C15	100PF	CAP CER 100PF 50V 5% C0G 0402	KEMET	C0402C101J5GAC
11	1	C16	2.0PF	CAP CER 2PF 50V 0.25PF C0G 0402	MURATA	GRM1555C1H2R0CA01B
12	1	C18	7.5PF	CAP CER 7.5PF 50V 0.5PF C0G 0402	MURATA	GRM1555C1H7R5DA01D
13	1	C19	5.6PF	CAP CER 5.6PF 50V +/- 0.25PF C0G CC0402	MURATA	GJM1555C1H5R6CB01D
14	2	C20, C21	3.3PF	CAP CER 3.3PF 25V 0.1PF -- 0402	AVX	04023J3R3BBSTR
15	5	C22, C25, C26, C28, C29	1000pF	CAP CER 1000PF 50V 5% C0G 0402	MURATA	GRM1555C1H102JA01D
16	2	C23, C24	11pF	CAP CER 11pF 50V 1% C0G 0402	AVX	04025U110FAT2A
17	1	C27	1UF	CAP CER 1UF 6.3V 20% X5R 0402	MURATA	GRM155R60J105ME19D
18	1	C30	2.2uF	CAP CER 2.2uF 6.3V 10% X5R 0402	MURATA	GRM155R60J225KE95
19	2	D1, D2	MSS1P3L	DIODE SCH 1A 20V MICROSMP SMT	VISHAY INTERTECHNOLOGY	MSS1P3L-M3/89A
20	1	J1	hdr_2x5	HDR 2X5 TH 50MIL CTR 254H AU 91L	SAMTEC	FTSH-105-04-F-D
21	1	J2	MM8030-2600B	CON COAX SMT 1.9MM SP 40H AU	MURATA	MM8030-2610B
22	1	J3	USB_MICRO_AB	CON 5 USB_MICRO_AB_RECEPT	molex	475900001

Table 1. Bill of materials

				ACLE RA SKT SMT 0.65MM SP 122H AU		
23	1	LED1	RED	LED RED CLEAR SGL 30MA SMT 0805	LITE ON	LTST-C171KRKT
24	1	LED2	GREEN	LED GRN SGL 30MA SMT 0805	LITE ON	LTST-C171KGKT
25	1	LED3	CLV1A-FKB-CJ1M1F1BB7R4S3	LED RED BL GRN SGL 50/25/25mA SMT	CREE, INC	CLV1A-FKB-CJ1M1F1BB7R4S3
26	1	L1	33NH	IND -- 0.033UH@100MHZ 200MA 5% 0402	MURATA	LQG15HS33NJ02D
27	1	L2	0.0047UH	IND -- 0.0047UH@100MHZ 300MA +/-0.3NF 0402	MURATA	LQG15HS4N7S02D
28	2	L3, L4	0.0068UH	IND -- 0.0068UH@100MHZ 300MA 5% 0402	MURATA	LQG15HS6N8J02D
29	1	L5	0.010UH	IND -- 0.01uH@100MHZ 300mA 5% 0402	MURATA	LQG15HN10NJ02
30	2	L6, L7	330 OHM	IND FER BEAD 330OHM@100MHZ 2.5A -- SMT	TDK	MPZ2012S331A
31	3	Q1, Q2, Q3	MMBT3904LT1G	TRAN NPN GEN 200MA 40V SOT-23	ON SEMICONDUCTOR	MMBT3904LT1G
32	1	R1 **DNP**	4.7K	RES MF 4.7K 1/10W 5% 0603	VISHAY INTERTECHNOLOGY	CRCW06034K70JNEA
33	1	R2	100	RES MF 100 OHM 1/16W 1% AEC-Q200 0402	VISHAY INTERTECHNOLOGY	CRCW0402100RFKED
34	2	R3, R6	10.0K	RES MF 10.0K 1/16W 1% AEC-Q200 0402	VISHAY INTERTECHNOLOGY	CRCW040210K0FKED
35	1	R4	10.0K	RES MF 10.0K 1/16W 1% 0402	KOA SPEER	WR04X1002FTL
36	1	R5	6.04K	RES MF 6.04K 1/16W 1% 0402	VISHAY INTERTECHNOLOGY	RK73H1ETTP6041F
37	2	R7, R8	330	RES MF 330 OHM 1/16W 5% 0402	VISHAY INTERTECHNOLOGY	CRCW0402330RJNED
38	1	R9	2.87K	RES MF 2.87K 1/16W 1% 0402	KOA SPEER	RK73H1ETTP2871F
39	3	R10, R11, R12	220	RES MF 220 OHM 1/16W 5% 0402	KOA SPEER	RK73B1ETTP221J
40	2	R13, R16 **DNP**	0	RES MF ZERO OHM 1/10W -- 0603	BOURNS	CR0603J/000ELF
41	2	R14, R15	3.74K	RES MF 3.74K 1/16W 1% 0402	KOA SPEER	RK73H1ETTP3741F
42	3	R17, R18, R19	1.0K	RES MF 1.0K 1/16W 1% 0402	YAGEO AMERICA	RC0402FR-071KL
43	9	SH1, SH2, SH3, SH4, SH5, SH6, SH7, SH8, SH9	0	ZERO OHM CUT TRACE 0603 PADS; NO PART TO ORDER	LAYOUT ELEMENT ONLY	LAYOUT ELEMENT ONLY
44	5	SW1, SW6, SW7, SW8, SW9	PB switch	SW SMT 4.0MM FMS 0.1A MAX 16V MAX ROHS COMPLIANT	BOURNS	7914J-1-000E
45	1	SW2	09.10201.02	SW SPDT RA SLD 12V 500MA TH	EAO SWITCH	09-10201-02

Table 1. Bill of materials

46	3	SW3, SW4, SW5	Electrode	Capacitive Single Electrode Square 7MM for PPR08X (Not a Part to Order)	NA	Electrode
47	1	S1	RF SHIELD	SHEILD CUSTOM SIZE SMD	NA	NA
48	3	TP1, TP3, TP4	TEST POINT WHITE	TEST POINT WHITE 40 MIL DRILL 180 MIL TH 109L	COMPONENTS CORPORATION	TP-105-01-09
49	7	TP2, TP9, TP10, TP11, TP12, TP13, TP14	TPAD_030	TEST POINT PAD 30MIL DIA SMT, NO PART TO ORDER	NOTACOMPONENT	NOTACOMPONENT
50	4	TP5, TP6, TP7, TP8	TPAD_040	TEST POINT PAD 40MIL DIA SMT, NO PART TO ORDER	NOTACOMPONENT	NOTACOMPONENT
51	3	TVS1, TVS2, TVS3 **DNP**	PGB2010402KRHF	DIODE ESD SUPPRESSOR BIDIR -- 12V 0402	LITTELFUSE	PGB2010402KRHF
52	1	U1	MKW01Z128	IC MCU ARM 48MHZ 128KB FLASH 16KB RAM 1.8-3.6V LGA60	Freescale Semiconductor	MKW01Z128CHN
53	1	U2	MC34671AEP	IC CHARGER LI-ION BATT 24V DFN8	FREESCALE SEMICONDUCTOR	MC34671AEP
54	1	U3	ZXCL280E5TA	IC VREG LDO 2.8V 150MA 2-5.5V SOT23-5	Zetex Inc	ZXCL280E5TA
55	1	Y1	32MHZ	XTAL 32MHZ 9PF -- SMT 3.2X2.5MM	NDK	EXS00A-CS02368

4. PCB Manufacturing Specifications

This section provides the specifications used to manufacture the KW01-RCD-RD development printed circuit board (PCB) described in this guide.

The KW01-RCD-RD development platform PCBs must comply with the following:

- The PCB must comply with Perfag 1D/3C (www.perfag.dk/en/)
- The PCB manufacturer's logo is required
- The PCB production week and year code is required
  - The manufacture's logo and week/year code must be stamped on the back of the PCB solder mask
  - The PCB manufacturer cannot insert text on the PCB either in copper or in silkscreen without written permission from NXP Semiconductor, Inc.
- The required Underwriter's laboratory (UL) Flammability Rating
  - The level is 94V-0 (ulstandards.ul.com/standard/?id=94)
  - The UL information must be stamped on the back of the PCB solder mask
  -

NOTE

A complete set of design files is available for the KW01-RCD-RD transceiver at the NXP website (www.nxp.com/KW0x) under "Software and Tools". These reference designs should be used as a starting point for a custom application.

4.1 Single PCB construction

This section describes individual PCB construction details.

- The KW01-RCD-RD PCB is a two layer, multi-layer design
- The PCBs contain no blind, buried or micro vias
- PCB data:
  - KW01-RCD-RD size: Approximately 5.9 x 8.1 mm (2.35 x 3.2 inches)
  - KW01-RCD-RD final thickness (Cu/Cu): 1.57 mm (0.62 inches) ±10 % (excluding solder mask)

The following table defines some of the layers of the completed PCB. The artwork identification refers to the name of the layer in commonly used terms.

The following table defines some of the layers of the completed PCB. The artwork identification refers to the name of the layer in commonly used terms.

Table 2. KW01-RCD-RD layer by layer overview

Layer	Artwork identification	File Name
1	Silkscreen Top	PSS.art
2	Top Layer Metal	L1_PS.art
3	Bottom Layer Metal	L2_SS.art
4	Silkscreen Bottom	SSS.art

IMPORTANT: The KW01-RCD-RD development board contains high frequency sub-GHz RF circuitry. As a result, component placement, line geometries and layout, and spacing to the ground plane are critical parameters. As a result, BOARD STACKUP GEOMETRY IS CRITICAL. Dielectric and copper thicknesses and spacing must not be changed; follow the stackup (see the following figure) information provided with the reference design.

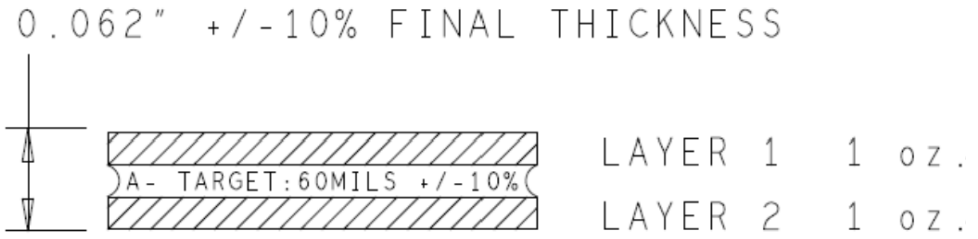

Figure 19. KW01-RCD-RD PCB stackup cross-section (two layer).

- Solder mask is required.
- Silkscreen is required.

4.2 Panelization

The panel size can be negotiated depending on production volume.

4.3 Materials

The PCB composite materials must meet the following requirements:

- Laminate: The base material (laminate) must be FR4. If the laminate material is changed, the RF electrical characteristics may change and degrade RF performance.
- Copper foil
  - Top and bottom copper layers must be 1 oz. copper
- Plating: All pad plating must be Hot Air Levelling (HAL)

4.4 Solder mask

The solder mask must meet the following requirements:

- Solder mask type: Liquid Film Electra EMP110 or equivalent
- Solder mask thickness: 10 – 30 µm

4.5 Silkscreen

The silkscreen must meet the following requirements:

- Silkscreen color: White
- Silkscreen must be applied after application of solder mask if solder mask is required
- Silkscreen ink must not extend into any plated-thru-holes
- Silk screen must be clipped back to the line of resistance

4.6 Electrical PCB testing

- All PCBs must be 100 % tested for opens and shorts
- Impedance measurement: An impedance measurement report is mandatory for single ended port (50 ohm traces)

4.7 Packaging

Packaging of the PCBs must meet the following requirements:

- Finished PCBs must remain in panel
- Finished PCBs must be packed in plastic bags that do not contain silicones or Sulphur materials. These materials can degrade solderability.

4.8 Hole specification/tool table

See the *ncdill-1-4.tap* file included with the Gerber files and the *FAB-29210.pdf* file.

4.9 File description

Files included with the download include Design, Gerber and PDF files. Gerber files are RS-274x format. Not all files included with the Gerber files are for PCB manufacturing.

PDF files included are:

- *FAB-29210.pdf* – Board fabrication and drawing
- *GRB-29210.pdf* – Metal layers, solder mask, solder paste and silk screen
- *SPF-29210.pdf* – Schematic

Design files are in Allegro format with OrCAD schematic capture.

5. Revision History

Table 3. Revision history

Revision number	Date	Substantive changes
0	10/2016	Initial release

How to Reach Us:

Home Page:
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