User manual

DA14580 Smart Dice application

UM-B-020

Abstract

This user manual describes an accelerometer application in the form of a dice, built around Dialog Semiconductor's low power DA14580 Bluetooth Smart Chip.

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1 Terms and definitions

PCB Printed Circuit Board

2 References

1. DA14580 Datasheet, Dialog Semiconductor

3 Introduction

Dialog has created a demonstration of the DA14580 chip showing its key differentiators, which are small size and low power consumption. These benefits can be shown in an application like a Bluetooth Smart wireless dice, as it requires small form factor and long operating time on a coin cell battery. The dice application is not only fun to play with, but can also be used by developers as a starting point for proprietary profile development. The PCB of the dice and host case are shown in Figure 1. The Dice application comes along with an iPhone app (https://itunes.apple.com/us/app/smartdice-by-dialog/id718852357?mt=8).

Source code of the DA14580 application is available in the reference designs area of the support site. The hardware (PCB and dice) is available from Dialog.

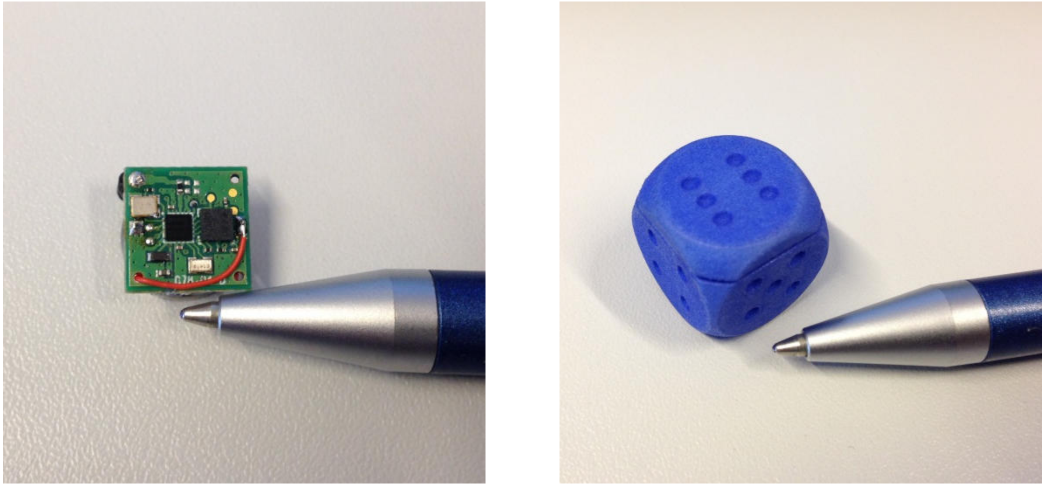


Figure 1: A small form factor PCB and host case

4 Software architecture

4.1 Basic functions

- The dice advertises for 30s with an advertising interval of 20ms.
- Wake-up is done by an accelerometer interrupt. By default the accelerometer is configured to create an interrupt when it detects a free fall. After wake up, the dice will start advertising again at the default 20ms interval.
- The iOS application enables notifications for the 3 axes X, Y, Z by writing the relative characteristic 0xFFA3, 0xFFA4, 0xFFA5 and by enabling the accelerometer by writing 1 to 0xFFA1 characteristic.
- After that the iOS application will start receiving notifications in the range -50 - +50 for each axis.
- Reading the 0xFFA1 characteristic will provide the battery level. (Please note that it is read once upon connection so it will not be updated in real time).
- After the bet is done in the iOS application and the “start” button is pressed the phone will start scanning for BLE devices. Device filtering is done in the iPhone app based on the advertised UUID where 0xFFA0 has to be detected.
- The battery level is also reported in the advertising events as a Manufacturer Specific element. The level is read once at the start of the advertisement.
- The default connection interval determined by iOS is 30ms. The dice will send a request to the iOS application to change the connection interval to 100ms. The iOS application will disconnect the dice immediately after the resting position is communicated.

5 Code overview and state machine

5.1 Source files

Group	File	Description
boot	system_ARMCM0.c boot_vectors.s hardfault_handler.c	Application start-up, ISR vectors, hard fault handler
arch	arch_main.c jump_table.c arch_sleep.c nmi_handler.c arch_system.c	Main loop, kernel scheduling, system setup, system clocks, common sysRAM/ROM code structure (jump_table), sleep modes API
	periph_setup.c	Peripheral modules initialization, GPIO pins assignment.
driver	rf_580.c	Radio
	gpio.c	GPIO driver
	wkupct_quadec.c	Wakeup module driver used in push button interface
	lis3dh_driver.c	Implements drivers for the accelerometer from STMicroelectronics
nvds	nvds.c	Non-volatile data structure
rwble	rwble.c	BLE core interrupt service routines
	rwip.c	BLE sleep function
profiles	accel.c accel_task.c	Accelerometer profile
app	app.c app_task.c app_sec.c app_sec_task.c	BLE application skeleton. Basic BLE and security functionality and message handling.
	app_accel_proj.c	Accelerator related functions
	app_accel_proj_task.c app_accel_task.c	Advertise/connection customization functions Connection and DB handling functions

5.2 State machine

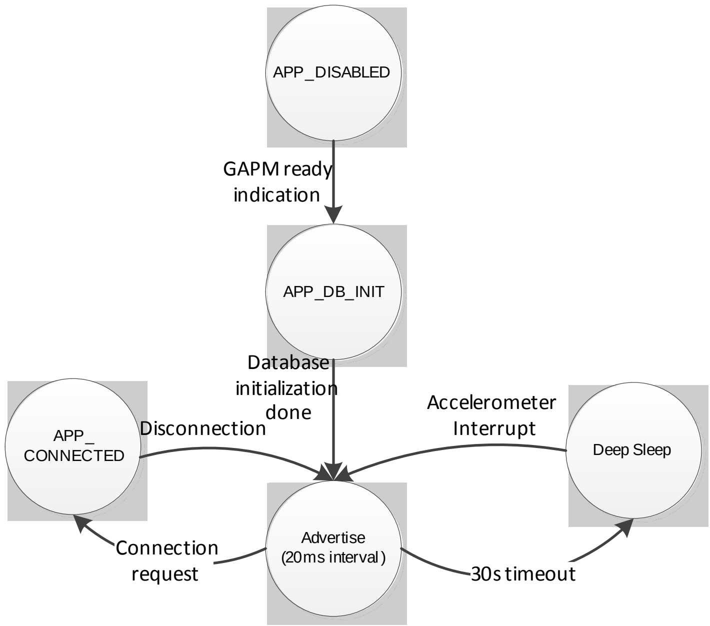


Figure 2: State machine of the dice application

After the device is initialized it will start advertising for 30 seconds. If no connection is established during that time the device will setup the accelerometer to detect a free fall and enter deep sleep. It can only be woken up by the accelerometer's interrupt which will be asserted once a free fall is detected. After the device is woken up it will advertise for 30 seconds.

If a connection is established the device will wait for notifications to be enabled in order to start reading values from the accelerometer and pass them as notifications to the application.

Once disconnected it will advertise for 30 secs and if no reconnection occurs it will go into deep sleep.

5.3 Initialization and establishing a connection

There are a couple of main tasks in the dice application. Tasks communicate to each other through a built-in messaging system. The sequence chart in Figure 2 illustrates the communication messages used across multiple applications to establish a connection with a peer device, i.e. iPhone in this case.

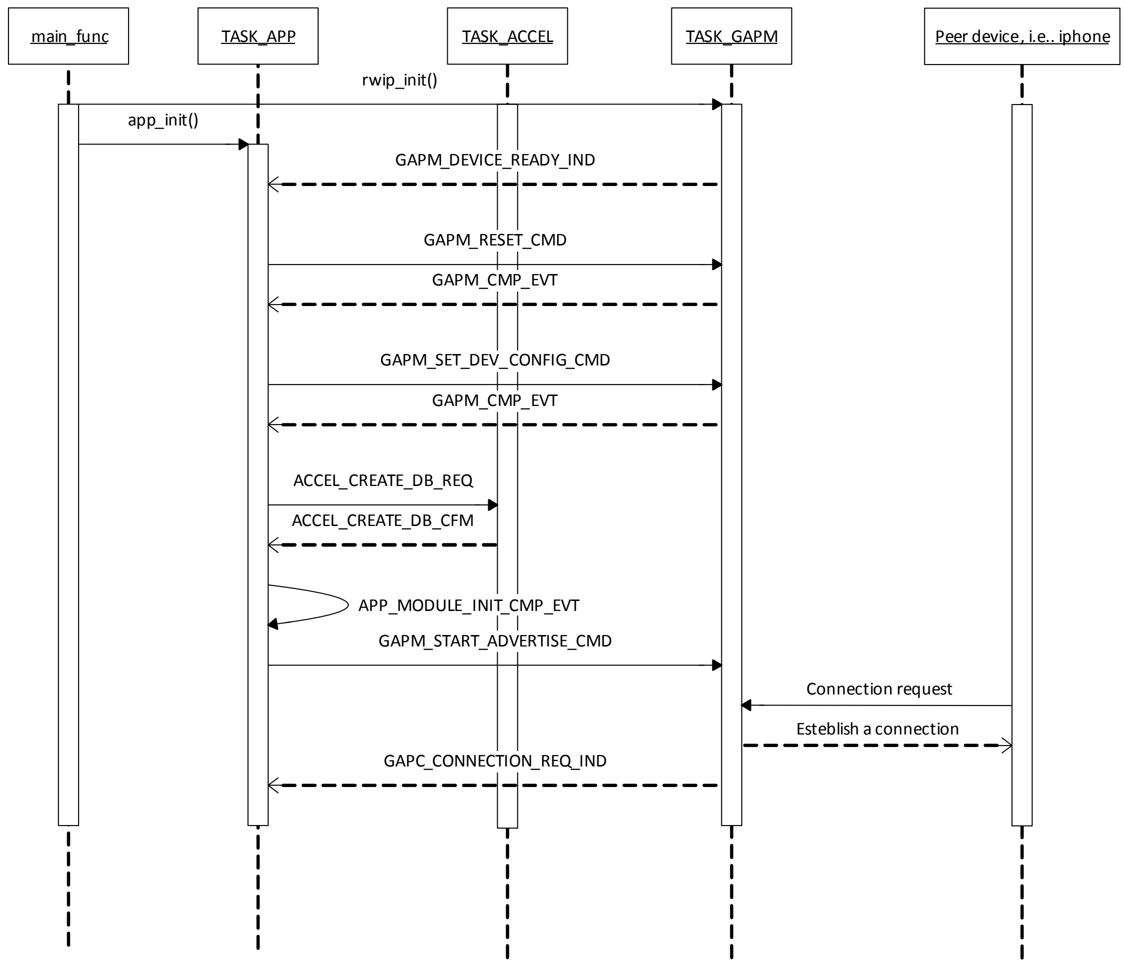
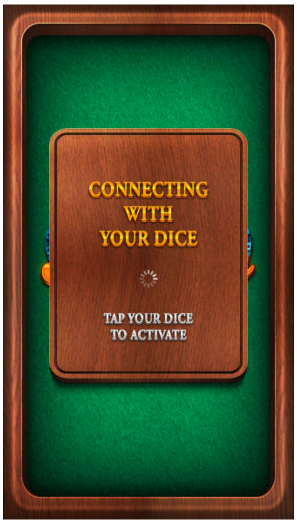


Figure 3: Message sequence chart

6 Dice iOS application

The application consists of several main screens and they are illustrated in the below table.

<table>
<tr>
<td>1. Start the SmartDice application on your iPhone, the app will scan for a dice.</td>
<td>2. After a connection between a dice and the iPhone, start button will become available.</td>
<td>3. Bet on a number and press start.</td>
</tr>
<tr>
<td>
</td>
<td>
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<tr>
<td>4. Roll the dice</td>
<td>5. The resting position of the dice is communicated over Bluetooth Smart to the app and a Win or Lose notice is provided.</td>
<td></td>
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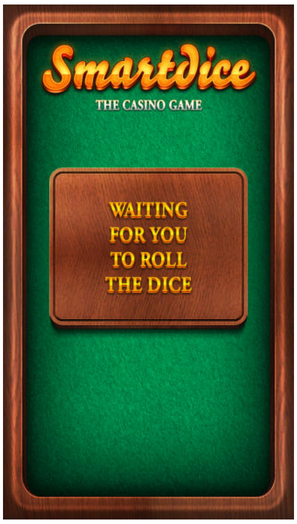
<tr>
<td>
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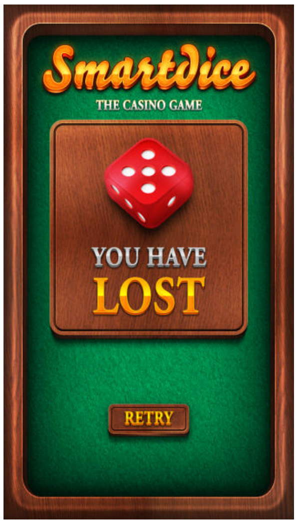
<td>
</td>
<td></td>
</tr>
</table>

7 Circuit of the DA14580 Accelerometer application in a Dice

Circuit schematics, board layout and bill of material (BOM) of the Smart Dice is available in the reference designs area of the support site.

The dice's orientation after a dice roll is electronically determined by a STMicro accelerometer. The dice's orientation is then forwarded to the DA14580 chip and transmitted to a smartphone over the established Bluetooth Smart link.

The 2.45 GHz antenna is formed by a quarter wavelength wire-antenna inside the dice.

The dice application circuit has been designed on a small two-layer FR-4 substrate, having a thickness of 0.71 mm. Both copper layers have a thickness of 0.0018 mm.

The DA14580 and the accelerometer are supplied by a small 3V coin-cell battery, soldered to the board.

The current version of the dice has only a 2 wire SWD port for debugging and programming. Developers creating their own PCB are advised to add a 2 wire UART on easily accessible probe points to make OTP programming of the dice easier.

7.1 Schematics

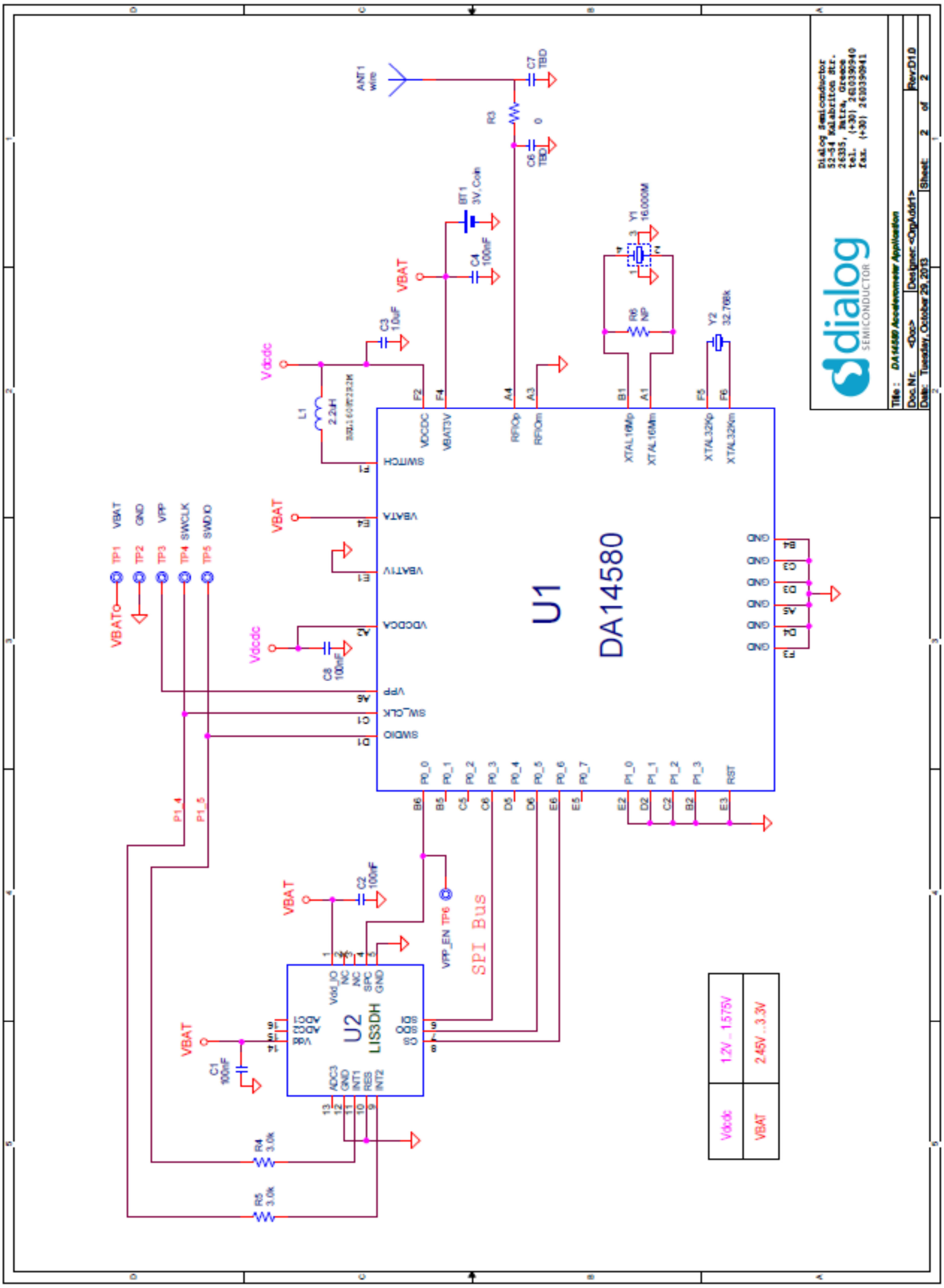


Figure 4: Circuit diagram of the DA14580 Bluetooth Smart chip in a Dice application

7.2 Board Layout

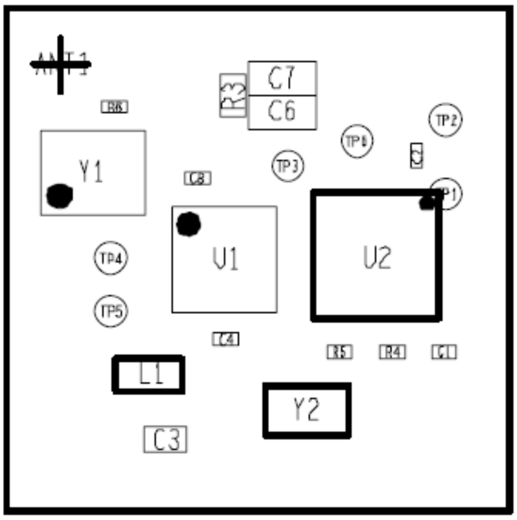


Figure 5: Top layer component placement

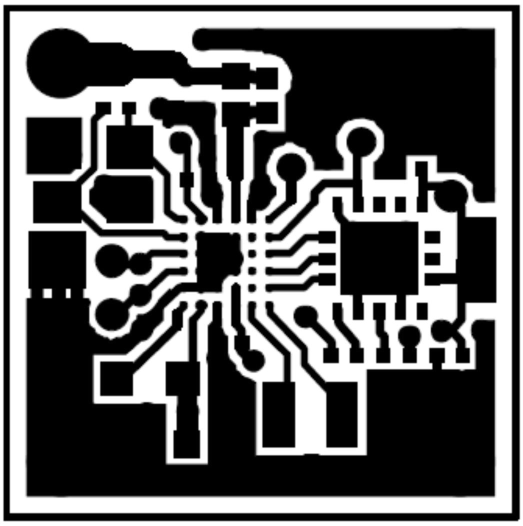


Figure 6: Top layer copper

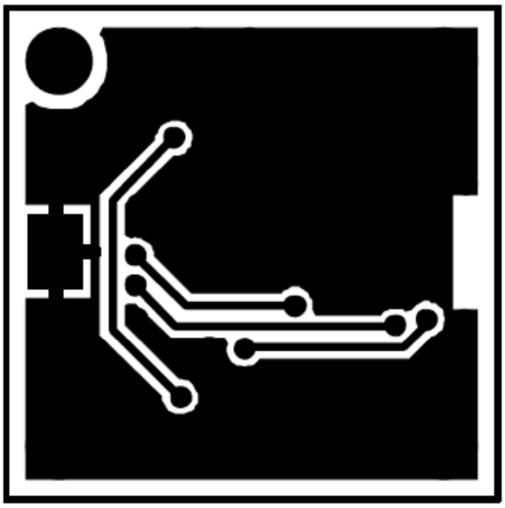


Figure 7: Bottom layer copper (battery)

7.3 Bill of Material

DA14580-wlcsp Bill of Materials

Released 31/5/2013
Updated 29/10/2013

Table 1 – BOM for the accelerometer dice application with the DA14580

REFDES	VALUE	Description	Manufacturer	Manufacturer Part	PACKAGE TYPE	QUANTITY
C1;C2;C4;C8	100nF	Capacitor	TDK	C0603X5R0J104K	C0603	4
C3	1.0uF	Capacitor	Taiyo Yuden	JMK105BJ105KV-F	C1005	1
L1	2.2uH	Capacitor	Taiyo Yuden	BRL1608T2R2M	L1608	1
U2	LIS3DH	Accelerometer	STMicro	LIS3DH	LGA-16	1
R4;R5	3k	Resistor	Yageo	RC0201JR-073KL	R0603	2
R3	0	Resistor	Vishay/Dale	CRCW04020000Z0ED	R1005	1
U1	DA14580		Dialog	DA14580	WLCSP34	1
Y1	16.000M	Crystal	NDK	NX2520SA	XTAL4P25X20	1
Y2	32.768k	Crystal	Abracon	ABS06-32.768kHz-9	XTAL_ABS06	1
NOT POPULATED						
C6	TBD			C_C1005_M_TBD	C1005	1
C7	TBD			C_C1005_M_TBD	C1005	1
BT1	3V, Coin	Coin cell with tabs	Renata	CR1225FH-LF	CR1225HT	1
R6	100k	Resistor	Yageo	RC0201JR-07100KL	R0603	1

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8 Revision history

Revision	Date	Description
1.0	23/05/2014	Initial version.

Status definitions

Status	Definition
DRAFT	The content of this document is under review and subject to formal approval, which may result in modifications or additions.
APPROVED or unmarked	The content of this document has been approved for publication.

RoHS Compliance

Dialog Semiconductor complies to European Directive 2001/95/EC and from 2 January 2013 onwards to European Directive 2011/65/EU concerning Restriction of Hazardous Substances (RoHS/RoHS2).
Dialog Semiconductor's statement on RoHS can be found on the customer portal https://support.diasemi.com/. RoHS certificates from our suppliers are available on request.

Contacting Dialog Semiconductor

Germany Headquarters
Dialog Semiconductor GmbH
Phone: +49 7021 805-0

United Kingdom
Dialog Semiconductor (UK) Ltd
Phone: +44 1793 757700

The Netherlands
Dialog Semiconductor B.V.
Phone: +31 73 640 8822

Email:
enquiry@diasemi.com

North America
Dialog Semiconductor Inc.
Phone: +1 408 845 8500

Japan
Dialog Semiconductor K. K.
Phone: +81 3 5425 4567

Taiwan
Dialog Semiconductor Taiwan
Phone: +886 281 786 222

Web site:
www.dialog-semiconductor.com

Singapore
Dialog Semiconductor Singapore
Phone: +65 64 849929

China
Dialog Semiconductor China
Phone: +86 21 5178 2561

Korea
Dialog Semiconductor Korea
Phone: +82 2 3469 8291