Application Brief

Optimizing Electric Toothbrushes and Other Personal Care Devices with Logic and Voltage Translation

Ian Graham

Functional Block Diagram

For the purpose of this report, a simplified electric toothbrush block diagram shows the logic and translation use cases. Simplified Block Diagram for Personal Care Electronics shows an example of this block diagram. Each red block has an associated use-case document. Table 1 and Table 2 provide links to the associated use-case document. For a complete block diagram, see the interactive online end equipment reference diagram for an electric toothbrush. This block diagram can be used in other electric personal care devices using internal motors, such as electric razors.

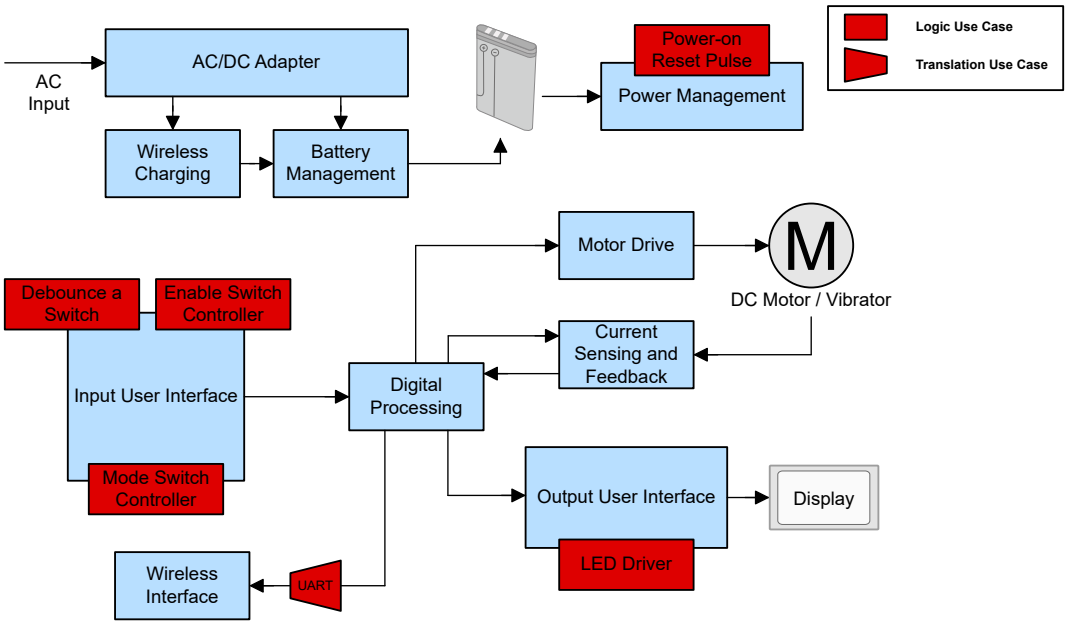

Figure 1. Simplified Block Diagram for Personal Care Electronics

Logic and Translation Use Cases

Each use case is linked to a separate short document that provides additional details including a block diagram, design tips, and part recommendations. The nearest block and use-case identifiers are listed to match up exactly to the use cases shown in the provided *simplified block diagram*.

Copyright © 2023 Texas Instruments Incorporated

Table 1. Logic Use Cases

Nearest Block	Use-Case Identifier	Use Case
Input User Interface	Debounce a Switch	*Debounce a Switch*
	Enable Switch Controller	*Push-Button Enable*
		Timed Pulse Enable
	Mode Switch Controller	Single Input Enable and Mode Controller
		Toggle a Device Between Two Modes
		Toggle a Device Between More than Two Modes
Power Management	Power Good	*Power-on Reset Pulse*
Output User Interface	LED Driver	*Drive Indicator LEDs*
		Increase the Number of Outputs on a Microcontroller

Table 2. Translation Use Cases

Nearest Block	Use-Case Identifier	Use Case
Wireless Interface	UART	*Translate Voltages for UART*

Shifting a Device Between Modes

Many electric personal care devices have multiple modes of operation, such as different power or speed levels. These modes are often controlled separately from the device power button. Turning the device on sets the device to a pre-defined state, from which a separate button can be used to switch the device mode.

There are multiple possible configurations of this setup that allow for different numbers of modes and control inputs. For these configurations, each mode output is tied to the enable of a motor driver. Only one of the mode outputs can be active at a time. All other mode outputs are low. Triggering the circuit causes the active mode output to change.

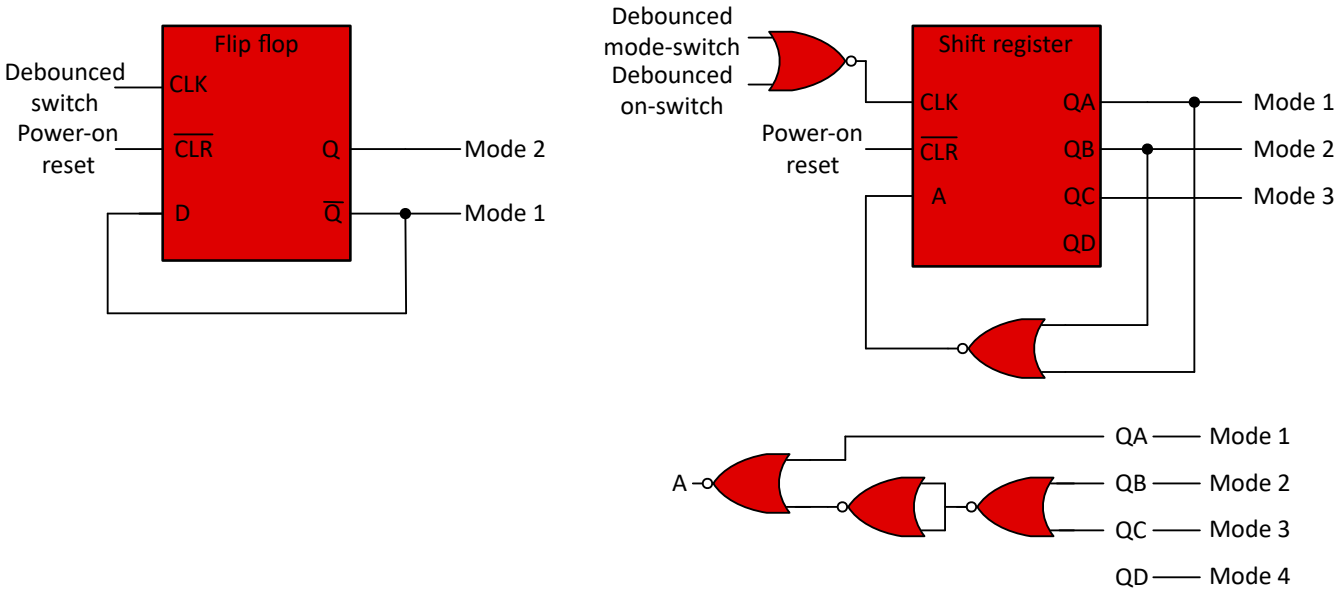

Figure 2. Separate Inputs for Mode Control and Device Enable

- The left image shows a configuration supporting 2 modes and the right image shows a configuration supporting more than 2 modes
- These configurations default to mode 1 being active when the device is turned on
- Expanding the number of modes can be done by expanding the logic between the shift register output an input. An example expanding the number of modes from 3 to 4 is shown.

Copyright © 2023 Texas Instruments Incorporated

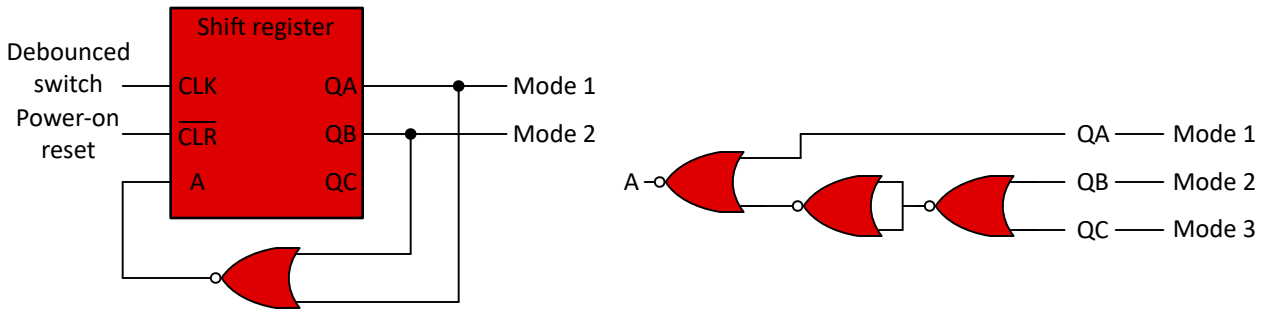

Figure 3. Single Input for Mode Control and Device Enable

- This configuration has a "mode 0" in which all of the modes are turned off. The device defaults to mode 0 and returns to mode 0 after cycling through the other modes.
- Expanding the number of modes can be done by expanding the logic between the shift register output and input. An example expanding the number of modes from two to three is shown.

Need additional assistance? Ask our engineers a question on the *TI E2E™ Logic Support Forum*.

Table 3. Recommended Parts

Part Number	AEC-Q100	V_{CC} Range	Function	Features
SN74LVC1G08		1.65 - 5.5 V	D-type flip flop	1 channel, inverted output
SN74LVC1G08-Q1	✓			
SN74LVC2G74		1.65 - 5.5 V	D-type flip flop	1 channel, asynchronous clear, inverted output, preset
SN74LVC2G74-Q1	✓			
SN74HCS164		2 - 6 V	Shift register	8 bit, Schmitt-trigger inputs, QFN/DYY available
SN74HCS164-Q1	✓			
SN74HCS02		2 - 6 V	NOR gate	4 channel, Schmitt-trigger inputs
SN74HCS02-Q1	✓			
SN74AHC1G02		2 - 6 VCC	NOR gate	1 channel

For more devices, see the *online parametric tool* where devices can be sorted by desired voltage, output current, and other features.

Copyright © 2023 Texas Instruments Incorporated

IMPORTANT NOTICE AND DISCLAIMER

TI PROVIDES TECHNICAL AND RELIABILITY DATA (INCLUDING DATA SHEETS), DESIGN RESOURCES (INCLUDING REFERENCE DESIGNS), APPLICATION OR OTHER DESIGN ADVICE, WEB TOOLS, SAFETY INFORMATION, AND OTHER RESOURCES “AS IS” AND WITH ALL FAULTS, AND DISCLAIMS ALL WARRANTIES, EXPRESS AND IMPLIED, INCLUDING WITHOUT LIMITATION ANY IMPLIED WARRANTIES OF MERCHANTABILITY, FITNESS FOR A PARTICULAR PURPOSE OR NON-INFRINGEMENT OF THIRD PARTY INTELLECTUAL PROPERTY RIGHTS.

These resources are intended for skilled developers designing with TI products. You are solely responsible for (1) selecting the appropriate TI products for your application, (2) designing, validating and testing your application, and (3) ensuring your application meets applicable standards, and any other safety, security, regulatory or other requirements.

These resources are subject to change without notice. TI grants you permission to use these resources only for development of an application that uses the TI products described in the resource. Other reproduction and display of these resources is prohibited. No license is granted to any other TI intellectual property right or to any third party intellectual property right. TI disclaims responsibility for, and you will fully indemnify TI and its representatives against, any claims, damages, costs, losses, and liabilities arising out of your use of these resources.

TI’s products are provided subject to TI’s Terms of Sale or other applicable terms available either on ti.com or provided in conjunction with such TI products. TI’s provision of these resources does not expand or otherwise alter TI’s applicable warranties or warranty disclaimers for TI products.

TI objects to and rejects any additional or different terms you may have proposed.

Mailing Address: Texas Instruments, Post Office Box 655303, Dallas, Texas 75265
Copyright © 2023, Texas Instruments Incorporated