

# User Manual DA7280 Performance Board UM-AU-011



## Abstract

This document is the User Manual for the DA7280 Performance Board, 359-02-B.



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# **1** Terms and Definitions

359-02-B	Performance Board PCB containing DUT, LRA and accelerometer circuitry
DA7280	Dialog Semiconductor's Haptic Driver I.C
DRO	Direct Register Override
DUT	Device Under Test
ERM	Eccentric Rotating Mass
ETWM	Edge Triggered Waveform Memory
GUI	Graphical User Interface, see SmartCanvas definition below.
I <sup>2</sup> C	Inter-Integrated Circuit communication standard
LRA	Linear Resonant Actuator
РСВ	Printed Circuit Board
PWL	Piecewise-Linear time and amplitude pairs for defining snippets in waveform memory
PWM	Pulse Width Modulation
RTWM	Register Triggered Waveform Memory
SmartCanvas	Dialog Semiconductor's (GUI) software tool for controlling DA7280 over USB
SAM3U	Dialog Semiconductor's USB Module for I <sup>2</sup> C communication over USB
USB	Universal Serial Bus
WLCSP	Wafer Level Chip Scale Package

## 2 References

- [1] DA7280, Datasheet, Dialog Semiconductor
- [2] 359-02-B\_SCH.pdf, Performance Board Schematic

# 3 Introduction

This is the DA7280 Performance Board user manual. It describes how to use the 359-02-B to experience the haptic capabilities of DA7280 with the supplied LRA. DA7280 is configured and controlled by Dialog Semiconductor's SmartCanvas<sup>™</sup> graphical user interface (GUI) over USB. DA7280 is capable of driving either LRA or ERM type motors, but this User Manual will focus on usage with the supplied LRA.

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# 4 Quick Start Setup

- 1. Install the GUI.
- 2. Connect the USB cable from the computer to the Performance Board, if this is the first-time connecting Windows will automatically install Dialog's USB Drivers.
- 3. Check that the LRA is connected to header J4.
- 4. Isolate the Performance Board from hard surfaces as this can dampen the haptic feedback. For example, the foam inserts shipped with the Performance Board is ideal.
- 5. Open the GUI.
- 6. In the popup window press **Download Default Setup Scripts**, this enables DA7280 to work with the cap sense buttons on the PCB.
- 7. Pressing B0, B1 or B2 cap sense buttons on the PCB will trigger haptic sequences.



# 5 Hardware and Software Prerequisites

The GUI <u>must</u> be installed before plugging in the DA7280 Performance board hardware on a Windows<sup>®</sup> 7 or Windows<sup>®</sup> 10 operating system. The DA7280 GUI installation file is included with the Performance Board kit. Run the .exe file to start the installation.

The latest version of the GUI can be found at https://support.dialog-semiconductor.com/ under the PMIC & Audio & Haptics section.

## 5.1 SmartCanvas GUI Setup

Follow the steps in the Setup Wizard:

1. Click the - I accept the agreement option button.

Please read the following important information before continuing.	6
	V
Please read the following License Agreement. You must accept the terms of this agreement before continuing with the installation.	
Dialog Smart Canvas Software Package Licensing Agreement	
	- 0
THIS LICENSING AGREEMENT REGULATES YOUR USE OF THE SOFTWARE	
PRODUCTS DESCRIBED HEREIN AND PROVIDED BY DIALOG SEMICONDUCTOR (UK) LTD ("DIALOG").	
IF YOU (INDIVIDUAL OR LEGAL ENTITY, ALSO REFERRED TO AS ") ICENSEE" HEREIN) HAVE ALREADY SIGNED OR ASSENTED TO BE BOUND	
BY ANOTHER SOFTWARE LICENSING AGREEMENT WITH RESPECT TO THE	-
I accept the agreement	
I do not accept the agreement	

Figure 1: License Agreement

2. Click Next.



Figure 2: Create a Desktop Item

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3. Click Install.



Figure 3: Install the GUI

4. Clear the Launch DA7280 GUI check box and click Finish.



**Figure 4: Finish Setup** 

5. Connect the universal serial bus (USB) cable from the Performance Board printed circuit board (PCB) to the computer.

Windows will now install the required drivers.



#### **Figure 5: Installing Driver Windows Notification**

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Driver Software Installation		23
Dialog USB-Lab IO installed		
Dialog USB-Lab IO	Finished, restart required	
		Close

Figure 6: Installation Complete

6. Click the desktop icon to run the **DA7280 GUI** 



Figure 7: Desktop Icon



## 6 Hardware Overview

The board is powered and controlled from the onboard USB circuitry. The device-under-test (DUT) side can be completely isolated from the USB controller side both in terms of power and I<sup>2</sup>C, or general purpose interface (GPI) signals, by de-soldering the solder bumps connections.



**Figure 8: Performance Board Functionality** 

#### 6.1 Power

The board and DA7280 are powered from the 5 V USB power supply (J3), additional external power supplies are not required. VDDIO is powered from an onboard, regulated 1.8 V supply. DA7280 is capable of driving 250 mA into the linear resonant actuator (LRA) load, so the USB power is adequate for most applications. When driving with Double Output Current Range enabled and driving 500 mA, supply VDD from an external supply.

To externally power the board and take accurate current measurements, de-solder the VDD and VDDIO solder bumps and connect the supplies via the labeled through-hole connections, see **Power connections** in Figure 8.When taking current measurements on the board, remove resistor R5 this powers down the accelerometer.

## 6.2 I<sup>2</sup>C Communications

The GUI communicates to the DA7280 through Dialog's USB to  $I^2C$  interface. DA7280 slave address is 0x4A, when adding the R/W bit the  $I^2C$  read = 0x94 and the  $I^2C$  write = 0x95.

To use external I<sup>2</sup>C communication, de-solder the SDA and SCLK solder bumps and connect the external I<sup>2</sup>C wires into the through-hole connections, labeled SCLK and SDA, see I<sup>2</sup>C and GPI connections in Figure 8.

If external I<sup>2</sup>C signaling is used, the VDDIO voltage level should be set to the external I<sup>2</sup>C signal voltage level.

#### 6.3 DA7280

DA7280 is located in either position U1 (QFN) or U2 (WLCSP), see Figure 8, depending on the supplied package variant on the board. The silicon in both package variants is identical.

After power-on reset, download the setup script see 7.1.1 for the supplied LRA. This ensures the correct DC parameters are driving the LRA according to the LRA's datasheet. If a different LRA is used, the settings should be adjusted according to that specific LRA's electrical parameters.

To drive the LRA DA7280 outputs PWM differential signals to two locations on the board:

- a. Solder pads labeled OUTP and OUTN
- b. J4 header pins labeled OUTP and OUTN.

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Connect the LRA to only one of these positions.

Filtered OUT\_P and OUT\_N signals from DA7280 are accessed from the OUTP\_F and OUTN\_F pins (J2). Connect J2 to an oscilloscope for signal monitoring and tuning purposes, see Section 8.

#### 6.4 Accelerometer

A high-precision accelerometer (U4) is fitted to capture the acceleration profile of the LRA see Figure 8. This is used to evaluate and tune the LRA's performance. See Section 8.

#### 6.5 Metal Mass Connection

To create a reference 100-gram mass, tightly screw the metal mass to the PCB, see Figure 9. This is useful for evaluating LRA performance with respect to the amount of acceleration (g) the LRA produces attached to this reference weight.

If fly wiring power or control signals, ensure that these connections do not electrically short to the metal mass. A thin piece of card is placed between the mass and the PCB; also electrical insulating tape could be used.



#### Figure 9: PCB with Metal Mass

#### 6.6 LRA Connection

Fix the LRA to the top of the PCB, glue or double sided sticky pads can be used. Ensure the LRA is firmly connected and has no movement when been driven to reduce damping. If using glue to connect the LRA to the PCB, ensure the glue does not enter the LRA housing through any relief openings on the LRA.

Connect the LRA terminals to the OUT\_P and OUT\_N header (J4), see Figure 9. The orientation of LRA terminals to the header pins is not important.

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# 7 Software Control

After starting the GUI this popup setup window is presented to the user, pressing **Download Default Startup Scripts** button will set DA7280 in Edge Triggered Mode so the cap sense buttons trigger haptic sequences. Close Window will close the window while not setting up DA7280 in any mode.



Figure 10: Performance Board Setup

The main window of the GUI looks like this, check the status of the following connections:

- a. Bus and USB communication LEDs are green.
- b. Enable/Disable Polling button is green and states Enabled.



Figure 11: Main GUI Window

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## 7.1 LRA Setup Scripts

There are three setup scripts bundled with the GUI for the supplied Jahwa 1040 LRA. These scripts include specific LRA configuration parameters, DA7280 feature configuration parameters, and waveform memory data; these are described in section 7.1.3.

#### 7.1.1 Load LRA Setup Scripts

To download the scripts:

1. In the File I/O window, click on the Load File button, see Figure 12.

File I/O Load/Save –		
Load File	Save All Registers	
File Format: 🔵 Number 🔿 Name		
Scripting Mode		

#### Figure 12: File I/O

2. Select the required .txt download script for the Jahwa LRA from the **Load Register Dump** popup window, see Figure 13. For the supplied LRA only download scripts with 'JAHWA\_1040' prefix.

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Coad Register Dump	Disk (C:) ▶ Dialog Semiconductor ▶ Haptics ▶ DA7280 GUI (CUSTOMER) ▶ files ▶	
Organize 🔻 New folder		
🚖 Favorites	Name	Date modified
Downloads	Archive	03/10/2018 08
🔚 Recent Places	📕 test_audio	03/10/2018 08
🧮 Desktop	ALPS_AFT14A901D_ACCEL_OFF_FRQ_OFF_SINE_WIDEBAND	23/08/2018 14
😻 Dropbox	ALPS_AFT14A901D_ACCEL_OFF_FRQ_ON	23/08/2018 14
	BLDC_C0625B002F	02/10/2018 09
Desktop	BVM 120830 WM ACCEL OFF FRO OFF SINE WIDEBAND	23/08/2018 14
Libraries	BVM 120830 WM ACCEL OFF FRO ON	23/08/2018 14
Documents	BVM 120830 WM ACCEL ON FRO ON	23/08/2018 14
D J Music	BVW 1040 WM ACCEL OFF FRO OFF SINE WIDEBAND	23/08/2018 14
Pictures	BVW 1040 WM ACCEL OFF FRO ON	23/08/2018 14
b 🗐 Subversion	BVW 1040 WM ACCEL ON FRO ON	23/08/2018 1
Videos	JAHWA 0832(205Hz) ACCEL OFF RS ON	09/08/2018 1
Alan Yeung	JAHWA 0832(235Hz) ACCEL OFF RS ON	09/08/2018 1
Computer	JAHWA 0832 ACCEL OFF RS ON	23/08/2018 1
📬 Network	JAHWA_0934B_ACCEL_OFF_RS_ON	09/08/2018 1
Control Panel	JAHWA 1030_FREQ_TRACK_ON_RS_ON	09/08/2018 1
👿 Recycle Bin	JAHWA 1034 FREQ TRACK ON RS ON	09/08/2018 1
DA7280	JAHWA 1035 FREQ TRACK ON RS ON	09/08/2018 1
B Hornet	JAHWA 1040 FREQ TRACK OFF SINE	23/08/2018 1
bortcuts	JAHWA 1040 FREQ TRACK ON	23/08/2018 1
	JAHWA 1040 FREQ TRACK ON RS ON	23/08/2018 1
	JAHWA 122792 ACCEL OFF RS OFF	23/08/2018 1
	JINLONG ERM 0720	02/10/2018 08
	MPLUS 0832 FREQ TRACK ON	11/09/2018 1
	PMV1030 FREQ ON RS ON WM	12/07/2018 1
	SEMCO 0825	12/07/2018 14
	SEMCO_1030_FREQ_ON_RS_ON_WM	12/07/2018 10
	STARTUP_EDGE_TRIGGERED	23/08/2018 14
	VLV_1030_FREQ_TRACK_ON_RS_ON_WM	12/07/2018 10
	XINJIN_0825	14/06/2018 10
	YJM L0832A FREO TRACK ON	23/08/2018 1

#### Figure 13: Load Register Dump

#### 7.1.2 Save All Registers

To save the current status of DA7280 registers:

1. In the File I/O window, click on Save All Registers, see Figure 14.

File I/O Load/Save —	
Load File	Save All Registers
File Format: 🔘	Number 🔿 Name
Scripting Mod	de

Figure 14: File I/O

- 2. In the Save All Registers dialog box, in the File name field, type in the file name.
- 3. In the **Save All Registers** dialog box, in the **Save as type** field, select the file format using the drop-down menu.

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#### Note:

- a. Normally **.txt** is used however **.csv** format also saves the IRQ status registers. The **.csv** format is useful for debugging, see Figure 15.
- b. The **File Format** options **Number** or **Name** will save the registers either by register number or by register name.



Figure 15: Save All Registers Dialog Box



#### 7.1.3 Setup Scripts for Supplied LRA

The JAHWA\_1040 LRA setup scripts include specific Jahwa configuration parameters, DA7280 feature configuration parameters, and waveform memory data. This LRA is also known as the 1040 model. This LRA has fast rise time and the Acceleration feature of DA7280 does not need to be enabled.

This LRA has the following specifications.

- Rated Voltage = 2.5 V(rms)
- Frequency = 170 Hz ± 10 Hz
- Vibration = 2.0 G
- Rated current = 170 mA
- Noise = 35 dB (max)
- Rise time (50 %) = max 10 ms
- Fall time (50 %) = max 50 ms
- Measured impedance =  $13 \Omega$
- Measured inductance = 353 μH



Figure 16: LRA Characteristics Graph

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The following 3 setup scripts are provided with the GUI for the supplied LRA. To Load these scripts see section 7.1.1

#### 7.1.3.1 JAHWA\_1040\_FREQ\_TRACK\_ON

The JAHWA\_1040\_FREQ\_TRACK\_ON.txt script sets up the DA7280 to enable the features shown in Table 1.

Table 1: JAHWA\_1040\_FREQ\_TRACK\_ON script features:

Feature	Status
Frequency tracking	ON
Acceleration	OFF
Rapid stop	OFF

After the scripts have loaded, the GUI shows the parameter settings as applied by the setup script.

ttings	Actuator/Supply Information
Drive Type	ADC VDD
-	Measured VDD supply
C ERM LRA Coin	
Operation Mode	ADC_VDD (V) 4.916016
Register triggered waveform memory	
- Settings	Ξ
Frequency Tracking On	- Impedance/Resonant Frequency Initial Settings
Acceleration Off	Features set by script
	Resonant Frequency (Hz) 169.29
Rapid Stop Off	
Abs Max (V)	Impedance (Ω) 22
2.5038	Inductance (AP)
	Calculated/cet by
Nom Max (V)	LRA Datasheet
2.0124	Impedance / Resonant Frequency Status
	Resonant Frequency (Hz) 175,57
0.2014	
Override Value	Impedance (Ω) 13.69
0.6004	
	Measured Parameters

Figure 17: JAHWA\_1040\_FREQ\_TRACK\_ON Parameters

The measured resonant frequency and impedance of the supplied LRA are shown in the GUI, see Figure 17. The Abs Max and Nom Max voltages for the LRA are calculated and set in the GUI by the script as follows:

- Abs Max = (I<sub>MAX</sub> \* 1.1) \* measured impedance = 2.51 V
- Nom Max = (measured impedance \* I<sub>MAX</sub>) \* 0.707 = 2 V

#### Notes:

- 1. These are conservative settings following LRA manufacturer's recommendations.
- 2. The Impedance and Inductance values after downloading setup scripts are not updated, but the underlying registers in DA7280 are set correct for the LRA.

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Figure 18: JAHWA\_1040\_FREQ\_TRACK\_ON Sequences

The haptic sequences loaded from the setup scripts are displayed in the GUI, see Section 7.3. For the JAHWA\_1040\_FREQ\_TRACK\_ON script, the sequences are shown in Figure 18.

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#### 7.1.3.2 JAHWA\_1040\_FREQ\_TRACK\_ON\_RS\_ON

The JAHWA\_1040\_FREQ\_TRACK\_ON\_RS\_ON.txt script sets up the DA7280 to enable the features shown in Table 2.

#### Table 2: JAHWA\_1040\_FREQ\_TRACK\_ON\_RS\_ON script features:

Feature	Status
Frequency tracking	ON
Acceleration	OFF
Rapid stop	ON

After the scripts have loaded, the GUI shows the parameter settings as applied by the setup script. See Figure 19

ettings	Actuator/Supply Information
Drive Type	ADC VDD
Cerm LRA Coin	
Operation Mode	ADC_VDD (V) 4.916016
Register triggered waveform memory	
- Settings	5 II L
Frequency Tracking On	Impedance/Resonant Frequency Initial Settings
Acceleration Off	Resonant Frequency (Hz) 169.29
Rapid Stop On	
Abs Max (V)	Impedance (Ω) 22
2.3166	Inductance (uH) 50
Nom Max (V)	
2.0124	Impedance / Resonant Frequency Status
I Max (A)	
0.2014	Resonant Frequency (Hz) 175.57
Override Value	
	Impedance (Ω) 13.69
0.6004	

Figure 19: JAHWA\_1040\_FREQ\_TRACK\_ON\_RS\_ON Parameters

			-	
	ser	IVI		
-	301		an	uu





Figure 20: JAHWA\_1040\_FREQ\_TRACK\_ON\_RS\_ON Sequences

The haptic sequences loaded from the setup scripts are displayed in the GUI, see Section 7.3. For the JAHWA\_1040\_FREQ\_TRACK\_ON\_RS\_ON script, the sequences are shown in Figure 20.

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USer	Manual
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#### 7.1.3.3 JAHWA\_1040\_FREQ\_TRACK\_OFF\_SINE

This script drives the output in sinewave mode. This mode reduces the LRA's audibility by driving a sine wave rather than square waves.

Frequency tracking is off; see Table 3, and the Waveform Memory sequences specify the drive frequency to allow wideband haptic effects.

#### Table 3: JAHWA\_1040\_FREQ\_TRACK\_OFF\_SINE script features:

Feature	Status
Frequency tracking	OFF
Acceleration	OFF
Rapid stop	OFF

After the scripts have loaded, the GUI shows the parameter settings as applied by the setup script see Figure 21.

ettings	Actuator/Supply Information
Drive Type	ADC VDD
Operation Mode Register triggered waveform memory	ADC_VDD (V) 4.916016
Settings Frequency Tracking Off	
Acceleration Off Rapid Stop Off	Resonant Frequency (Hz) 170.02
Abs Max (V)	Impedance (Ω) 22
Nom Max (V)	Inductance (uH) 50
2.0124 I Max (A)	Impedance / Resonant Frequency Status
0.2014	Kesonant Frequency (Hz) 175.57
0.9796	impedance (Ω) 13.69

Figure 21: JAHWA\_1040\_FREQ\_TRACK\_OFF\_SINE Parameters



Short click ~12 ms	12 ms click brake
7 ms click brake	Buzz @ 140Hz, buzz @ 200Hz
Modulating buzz 150 Hz to 190 Hz	Buzz @70
116 Hz ramp and	Testers 7
buzz at resonance	Very short subtle click
buzz at resonance	Very short subtle click

#### Figure 22: JAHWA\_1040\_FREQ\_TRACK\_OFF\_SINE Sequences

The haptic sequences loaded from the setup scripts are displayed in the GUI, see Section 7.3. For the JAHWA\_1040\_FREQ\_TRACK\_ON\_RS\_ON script, the sequences are shown in Figure 22.



# 7.2 Operating Modes

To select different modes for driving the LRA:

- 1. In Drive Type, select LRA, see Figure 23.
- 2. Use the drop-down menu in **Operation Mode** to select the required mode, see Figure 24. Each Operation Mode is described in detail in the following sub-sections.

👿 D	A728	0						
File	Op	otions	Tools	Sea	rch	View	He	lp
S	AM3U	Config	DA7	280				
U	SER	SYSTE	EM I	RQ	TOP	<u>o</u>	IP	<u>W</u> ave
	- Se	ttings Drive 1	Туре —	<b>0</b> 1 P	Δ		oin	_
		Opera (Inactiv	tion Mode	de				

#### Figure 23: Drive Type

ſ	Operation Mode	
	Register triggered waveform memory	$\vee$
L	Inactive mode	
_	Direct register override	
ſ	Playback from PWM data source	
	Register triggered waveform memory	
	Edge triggered waveform memory	
	n/a	

Figure 24: Operation Mode

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#### 7.2.1 Direct Register Override Mode (DRO)

In DRO mode haptic sequences are streamed to DA7280 via I2C input. The drive level of the output is set via Override value.

To use direct register override (DRO) mode:

- 1. In Drive Type, select LRA, see Figure 25.
- 2. Set the **Override** value.
- 3. Use the drop-down menu in **Operation Mode** to select **Direct register override**.

Setting the **Override** value and then setting the operating mode to **Direct register override** ensures optimal latency.

DA7280		10 Ø. I
Nr. Cystons Torts View Help SAVSU Carly CA7300 USIN 109 20534 P.Q Teasfam Newsy/ Table View	Direct register override mode	Come Comert canvas
Max     Auto:       Des Tore     Des Tore       State Inter     Des Tore       Des Tore     Des Tore	Device VDD monitoring p Solution for the second se	- Cancerdan Cancerdan Cancerdan Cancerdan Cancerdan Cancerdan Cancerdan Cancerdan Cancerdan Cancerdan Cancerdan Cancerdan Cancerdan Cancerdan Cancerdan Cancerdan Cancerdan Cancerdan Cancerdan Cancerdan Cancerdan Cancerdan Cancerdan Cancerdan Cancerdan Cancerdan Cancerdan Cancerdan Cancerdan Cancerdan Cancerdan Cancerdan Cancerdan Cancerdan Cancerdan Cancerdan Cancerdan Cancerdan Cancerdan Cancerdan Cancerdan Cancerdan Cancerdan Cancerdan Cancerdan Cancerdan Cancerdan Cancerdan Cancerdan Cancerdan Cancerdan Cancerdan Cancerdan Cancerdan Cancerdan Cancerdan Cancerdan Cancerdan Cancerdan Cancerdan Cancerdan Cancerdan Cancerdan Cancerdan Cancerdan Cancerdan Cancerdan Cancerdan Cancerdan Cancerdan Cancerdan Cancerdan Cancerdan Cancerdan Cancerdan Cancerdan Cancerdan Cancerdan Cancerdan Cancerdan Cancerdan Cancerdan Cancerdan Cancerdan Cancerdan Cancerdan Cancerdan Cancerdan Cancerdan Cancerdan Cancerdan Cancerdan Cancerdan Cancerdan Cancerdan Cancerdan Cancerdan Cancerdan Cancerdan Cancerdan Cancerdan Cancerdan Cancerdan Cancerdan Cancerdan Cancerdan Cancerdan Cancerdan Cancerdan Cancerdan Cancerdan Cancerdan Cancerdan Cancerdan Cancerdan Cancerdan Cancerdan Cancerdan Cancerdan Cancerdan Cancerdan Cancerdan Cancerdan Cancerdan Cancerdan Cancerdan Cancerdan Cancerdan Cancerdan Cancerdan Cancerdan Cancerdan Cancerdan Cancerdan Cancerdan Cancerdan Cancerdan Cancerdan Cancerdan Cancerdan Cancerdan Cancerdan Cancerdan Cancerdan Cancerdan Cancerdan Cancerdan Cancerdan Cancerdan Cancerdan Cancerdan Cancerdan Cancerdan Cancerdan Cancerdan Cancerdan Cancerdan Cancerdan Cancerdan Cancerdan Cancerdan Cancerdan Cancerdan Cancerdan Cancerdan Cancerdan Cancerdan Cancerdan Cancerdan Cancerdan Cancerdan Cancerdan Cancerdan Cancerdan Cancerdan Cancerdan Cancerdan Cancerdan Cancerdan Cancerdan Cancerdan Cancerdan Cancerdan Cancerdan Cancerdan Cancerdan
Data         Data           Constant         Bite         Bite <t< td=""><td>X         bits         Teach           Import (ch)         Teach (crists)         Teach (crists)           Import (crists)         Teach (crists)         Teach (crists)</td><td></td></t<>	X         bits         Teach           Import (ch)         Teach (crists)         Teach (crists)           Import (crists)         Teach (crists)         Teach (crists)	

Figure 25: GUI in DRO Mode

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#### 7.2.2 Register Triggered Waveform Memory (RTWM)

This mode allows the user to trigger haptic sequences stored in the Waveform Memory by using  $I^2C$  writes to DA7280.

- 1. In Drive Type, select LRA, see Figure 26.
- 2. Use the drop-down menu in **Operation Mode** to select **Register triggered waveform memory**.
- 3. In the Pattern window, use the drop-down menu in Sequence ID to select a sequence.
- 4. Click the **Sequence Start** button to trigger the chosen sequence.

AJ Cardy DA7280		Cette
100 EVCEN E0 Examina Honory ZohnVex Settrop     Cone Top     Cone Top	Register triggered waveform memory	@smartcany
Oren & A.A. Com     O	Filmer VDDIO VDD SCH Frequency Battery Temperature and UVLes Battery Temperature Sch Frequency ERFS Sersing and Actuator Diagnostics Fraction GPL 0 / PVML Rapid Stop Waveform Wigner GPL 0 / PVML Wettorm Wigner GPL 0 / PVML VDT	A communities     A commu
None           weight (b)         Log bool           000 (b)         Deel (b) (b)         Log bool           000 (b)         Deel (b) (b)         Deel (b) (b)         Log bool           000 (b)         DEEl (b)         Deel (b) (b)         Log bool           000 (b)         DEEl (b)         Deel (b)         Deel (b)         Log bool           000 (b)         DEEl (b)         Deel (b)         Deel (b)         Log bool           000 (b)         DEEl (b)         Deel (b)         Deel (b)         Log bool           000 (b)         DEEl (b)         Deel (b)         Deel (b)         Log bool           000 (b)         DEEl (b)         Deel (b)         Deel (b)         Log bool           000 (b)         DEEl (b)         Deel (b)         Deel (b)         Log bool           000 (b)         DEEl (b)         Deel (b)         Deel (b)         Log bool           000 (b)         DEEl (b)         Deel (b)         Deel (b)         Log bool           000 (b)         DEEl (b)         Deel (b)         Deel (b)         Log bool           000 (b)         DEEl (b)         Deel (b)         Deel (b)         Log bool           000 (b)         DEEl (b)         Deel (b)		

#### Figure 26: GUI in RTWM Mode

The haptic sequences in the Waveform Memory can be edited, created, and triggered from the Waveform memory editor, see Section 7.3.

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#### 7.2.3 Pulse Width Modulation Mode (PWM)

PWM mode is used to stream haptic sequences to DA7280 via the GPI\_0/PWM input pin where the output drive level is determined by the duty cycle of the PWM signal. The PWM signal contains envelope information only and the input PWM frequency is unrelated to the output PWM frequency or the resonant frequency setting. The duty cycle is interpreted differently defending if the **Acceleration** is enabled or disabled - see datasheet sections **Pulse Width Modulation Mode** and **General Data Format** for more details.

To drive the LRA in PWM mode:

- 1. Set the input PWM frequency to the lower end of the allowable range, 10 kHz to 250 kHz.
- 2. Actively drive the PWM signal via the GPI\_0/PWM pin.
- 3. In the **Impedance/Resonant Frequency Initial Settings** window of the GUI, set the resonant frequency and impedance of the LRA.

**Note**: Before selecting this mode, the PWM signal must be actively driving the GPI\_0/PWM pin otherwise DA7280 will generate an IRQ, which must be cleared manually.

#### 7.2.4 Edge Triggered Waveform Memory (ETWM)

In edge triggered waveform memory (ETWM) mode rising or falling edges, or both rising and falling edges, on GPI\_0/PWM, GPI\_1, and GPI\_2 pins trigger sequences from Waveform Memory, see Section 7.3. Set the registers shown in Figure 27 as required. See also section 7.6.

- GPI	
GPI0_SEQUENCE_ID	0 🗸
GPI0_MODE	Single pattern
GPI0_POLARITY	Rising edge 🔍
0x29	0x00 ÷
GPI_1_CIL	
GPI1_SEQUENCE_ID	1 🗸
GPI1_MODE	Single pattern
GPI1_POLARITY	Rising edge 🔍
0x2A	0x08
GPI 2 CTL	
GPI2_SEQUENCE_ID	2 🗸
GPI2_MODE	Single pattern
GPI2_POLARITY	Rising edge 🔍
0×2B	0x10 ÷

Figure 27: GPI Registers

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## 7.3 Waveform Memory Editor

The Waveform Memory editor is a powerful and intuitive tool for creating haptic effects stored in memory. Haptic effects in Waveform Memory are modified and viewed by selecting **Tools -> Waveform Memory Editor**, see Figure 28.

	A72	80					
File	0	ptions	Tools	Search	View	Help	
S	AM3U	Config	Scar Cus	n I2C tom Tabs			
U	SER	<u>S</u> YST	OTP	Program	mer		ivefo
Waveform Memory Editor							
	Settings Way to Haptics Converter						
		Drive	Type –	LRA	C	oin	ן
Operation Mode Register triggered waveform memory					ן		

Figure 28: Enabling the Waveform Memory Editor

**Note:** Before proceeding, select **Register Sync** -> **Read from Device** to read back the Waveform Memory from DA7280.

3mport 0	sport Read from Device	Winte to Device	Cherr Al O% [Delete Unused Snippets]	Show Acceleration
Kapanos     Orak     Teal unit (Man)		Page Anglines Unitives	G	Bage (drag han have
1 0 0	Lection <sup>64</sup> 68 1			

#### Figure 29: Register Syncing from DA7280 Memory

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#### 7.3.1 Setting Operation Mode

To trigger haptic sequences:

- 1. Select the USER tab
- 2. Use the drop-down menu in **Operation Mode** to select **Register triggered waveform memory**.

U	SER	<u>S</u> YSTEM	IRQ	TOP	<u>O</u> TP	<u>W</u> ave
	— Se	ttings				
	- -	- Drive Type				
			🔵 LR	А (	Coin	
		Operation I	Mode			$\equiv$
		Register tri	ggered w	aveform	memory	

Figure 30: Set RTWM Mode in Operation Mode

#### 7.3.2 Snippets Tab

In the Snippets tab, delete, create, and modify snippets by dragging and dropping the basic *Step* and *Ramp* piecewise-linear (PWL) snippets from the **Stages** window into the **Snippets** window. The time and amplitude parameters of each snippet can then be changed in the GUI.

**Note:** Snippets cannot be played directly the haptic effects can only be triggered once the snippet is added to the sequence memory.



Figure 31: Waveform Memory Editor Snippets Tab

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#### 7.3.3 Sequences Tab

After dragging and dropping snippets to create haptic sequences, the haptic sequences are played by clicking the green play buttons in the **Sequences** tab, see Figure 32. The played sequence can be looped by changing using the drop-down menu in **Playback Option**. To change the sequence name, click on the sequence identifier.



Figure 32: Waveform Memory Editor Sequences Tab

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#### 7.3.3.1 Changing Snippet Parameter Values

When the snippet is added to the sequence the user can control four snippet parameters:

- Gain: The gains that can be applied to the snippets are 0 db, -6 dB, -12 dB and -18 dB.
- **Timebase**: The unit time of the snippet depends on the FREQ\_WAVEFORM\_TIMEBASE bit of register SEQ\_CTL1. It can be (5.44, 21.76, 43.52, 87.04) ms or (1.36, 5.44, 21.76, 43.52) ms.
- Cycles: The snippet can be 1 cycle to 16 cycles.
- **Frequency Default**: From 26 Hz to 1024 Hz; If set to **Default**, the current frequency setting is used. Note that if using this for wideband patterns, frequency tracking should be switched off.

**Note:** The overall time of each sequence = Unit Time \* Cycles \* Timebase.



#### Figure 33: Two Snippet Sequence Example

Sequence Short Click, see Figure 33, is made up of Snippet 1 and Snippet 0, see Figure 34.

• Snippet 1 has an amplitude of 15 and a unit time of 4 ms. The overall time is:

$$4 * 5.44 \text{ ms} * 1 = 21.76 \text{ ms}$$

• Snippet 0 has an amplitude of 0 and a unit time of 1. This is silence for an overall time of:

$$1 * 21.76 \text{ ms} * 4 = 87.04 \text{ ms}$$



Figure 34: Snippets for the Two Snippet Sequence Example

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## 7.4 Wav to Haptics Converter

The Wav to Haptics converter allows .wav files to be converted to haptic patterns and the audio and haptic effect can be played back simultaneously.

Select Wav to Haptics Converter from the Tools menu and the press the Load File button.







Figure 36: Wav To Haptics Converter Plugin



- Load File
  - □ The GUI will navigate to the *test\_audio* folder bundled with the GUI. A number of sound effects .wav file are included for demonstration purposes.



Figure 37: Included Sound Effect Files

- Play Audio
  - □ Plays the audio track through the computers soundcard.
- Process Audio
  - □ The audio can be processed with the plug-ins basic filters these include low-pass filter, high-pass filter, Normalise, Gate Threshold, Compression and Boost Gain.
- Play Haptics
  - □ Plays the haptic sequence.
- Play with Audio
  - □ Plays haptic sequence and audio simultaneously.
- Export
  - □ Exports the haptic sequence as .txt, .csv or .bin file.

Note: Hoovering the mouse cursor over the GUI's sliders shows detailed description of each control.

		]
Audio Processing	]	
Low Pass Filter:	1964Hz	OFF
A	pply Low Pass Filte	r to remove Higher Tones from A
High Pass filter:	2646Hz	
Normalise:		

Figure 38: Detailed Descriptions of Controls

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## 7.5 IRQ

Interrupt requests in the form of events and warnings can occur in normal operation. To continue driving the LRA, these must be cleared in the GUI.

IRQ_EVENT1		IRQ_EVENT_WARNING	G_DIAG	IRQ_EVENT_SEQ_D	IAG	IRQ_STATUS1	
E_OC_FAULT	Low	E_LIM_DRIVE	Low	E_SEQ_ID_FAULT	Low	STA_OC	Low
E_ACTUATOR_FAULT	Low	E_LIM_DRIVE_ACC	Low	E_MEM_FAULT	Low	STA_ACTUATOR	Low
E_WARNING	Low	E_MEM_TYPE	Low	E_PWM_FAULT	High	STA_WARNING	Low
E_SEQ_FAULT	High	E_OVERTEMP_WARN	Low			STA_SEQ_FAULT	Low
E_OVERTEMP_CRIT	Low					STA_OVERTEMP_C	Low
E_SEQ_DONE	Low	ווכ				STA_SEQ_DONE	Low
E_UVLO	Low					STA_UVLO_VBAT_OK	High
E_SEQ_CONTINUE	Low					STA_SEQ_CONTINUE	Low
0x03	0x10	0x04	0x00	0x05	0x20	0x06	0x02
				TPO STATUS?		TPO MASK2	
OC M	Low	E TEST FREO FA	No fault	STA ADC SAT	Low	ADC SAT M	Low
ACTUATOR_M	Low	E_TEST_PHASE_FA	No fault	1			
WARNING_M	Low	E_TEST_IMP_FAULT	No fault	í l			
SEQ_FAULT_M	Low	E_TEST_CALIB_FA	No fault	j l			
OVERTEMP_CRIT_M	Low	E_TEST_BEMF_FA	No fault	j l			
SEQ_DONE_M	Low	E_TEST_ADC_SAT	No fault				
E UVLO M	Low	E_TEST_OTP_CRC	No fault				
	-	5	1				
SEQ_CONTINUE_M	Low						

Figure 39: IRQ Tab

To clear IRQ faults events click on buttons Clear Events and Clear Faults, see Figure 40.

Communication	۱ —			
Bus communication				
USB connect	tion			
USB device	A>dev0 v			
Recon	nect to device			
Enable/Disable	Polling			
	Enabled			
Board Status Device Activit	ty]			
Device Statu	s			
n/a	V			
PAT_OFF	~			
Automated Se	quences			
Clear Events	s Clear Faults			
Lock				

Figure 40: Clear IRQ Events and Faults





**Note:** In Embedded Mode operation, see Figure 41, the IRQs will self-clear when the playback ends. This is useful for systems with minimum interaction between the host and DA7280.

TOP	
TOP_CFG1	
EMBEDDED_MODE	High
ACTUATOR_TYPE	LRA
BEMF_SENSE_EN	Low
FREQ_TRACK_EN	Low
ACCELERATION_EN	Low
RAPID_STOP_EN	Rapid stop disa
AMP_PID_EN	Amplitude PID (
0x13	0x80 ÷

Figure 41: Embedded Mode

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## 7.6 Cap Sense Setup

The USB to I2C controller can be configured to ensure the USB does not interfere with the cap sense buttons. Set the IO Mode to **Input: High-Z** in the **Sam3U Config** tab, see Figure 42.

SAM3U Config DA7280				
Read SAM3U pins	Port E	DEVICE PIN	I0 Mode	I0 State
Reset USBIO States	PB0	GPI_0	Input: High-Z 🔍	High
Read Current Status	PB1	GPI_1	Input: High-Z 🔍	High
Continuous Polling	PB2	GPI_2	Input: High-Z 🔍	High
	PB3	NIRQ	Input: High-Z	High

Figure 42: SAM3U Configuration

Now set the operation mode to **ETWM** mode, see Figure 43.

Operation Mode	
Edge triggered waveform memory	$\sim$

Figure 43: ETWM Mode

Set the GPI controls as required for user defined operation. In this case **GPI0\_POLARITY** is set to **Falling edge** triggered, and **GPI0\_SEQUENCE\_ID** is set to **0**, see Figure 44. On receiving a falling edge on **GPI\_0** pin the first haptic sequence in the Waveform Memory will be triggered.

**Note:** The cap sense buttons voltage levels are high by default; pressing cap sense button pulls the line to ground triggering GPI 0 on the falling edge. Triggering on the rising edge would mean that on releasing the cap sense button the sequence would be triggered. A third option is to trigger on either rising or falling edges.

In **Multi sequence** mode, the rising edge will trigger the sequence denoted by **SEQUENCE\_ID**, while the falling edge will trigger the sequence located at SEQUENCE\_ID + 1.

GPI_0_CTL GPI0_SEQUENCE_ID GPI0_MODE GPI0_POLARITY 0x29	0 V Single sequenco Falling edge V 0x01 +
GPI_1_CTL GPI1_SEQUENCE_ID GPI1_MODE GPI1_POLARITY 0x2A	1   V     Single sequence     Rising edge     0x08
GPI_2_CTL GPI2_SEQUENCE_ID GPI2_MODE GPI2_POLARITY 0x2B	2 Single sequence Rising edge v

#### Figure 44: GPI\_0\_CTL Settings

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## 7.7 GPI Triggering from GUI

The GPIs can be controlled from the GUI's **SAM3U Config** tab by setting the **IO Mode** to **Output** and pressing the **IO State** button, see Figure 45.

SAM3U Config DA7280				
	- Port E	3		
Read SAM3U pins	USBIO	DEVICE PIN	IO Mode	IO State
Reset USBIO States	PB0	GPI_0	Output: PullUp 🛛 🗸	Low
Read Current Status	PB1	GPI_1	Output: PullUp 🛛 🗸	Low
Continuous Polling	PB2	GPI_2	Output: PullUp 🛛 🗸	Low
	PB3	NIRQ	Input: PullUp 🛛 🗸	High

Figure 45: Controlling GPIs from GUI

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# 8 Monitoring Drive Signals and Measuring Acceleration

When evaluating the system performance of the haptic driver and the LRA and for general tuning purposes, it is useful to go through the following procedure:

- 1. Place the DA7280 Performance Board on foam to isolate it from hard surfaces. This reduces damping of the LRA's motion.
- 2. Connect the oscilloscope channels 1 and 2 (yellow and green trace) to header J2 to monitor the filtered OUTP and OUTN signals. The filter cut-off is set at ~3.3 kHz.
- 3. The unfiltered OUTP and OUTN signals (header J4) are PWM signals at 187.5 kHz so looking at these makes little sense for analysis purposes.
- 4. Connect oscilloscope channels 3 (blue trace) to the header J1 and chose a suitable accelerometer axis which is depending on type of actuator, in this case the Z-AXIS.
- 5. Set the oscilloscopes trigger channel to trigger on the rising edge of channel 1. Now drive haptic patterns and observe the acceleration while also feeling the movement of the LRA with your hand.
- 6. The default 100nF caps (C13, C14, and C16) on the output accelerometer circuit set the bandwidth to be 50Hz. With VDD=1.8V, 1 g peak of acceleration is ~50 mV (peak).
  - a. For higher resolution measurements for this accelerometer changing these caps to 10nF is advisable. 1g of peak acceleration would then be ~150mV at 1.8V VDDIO.



#### Figure 46: Monitoring Signals



Figure 47: Measured Output Signals and Acceleration Profile

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# 9 Measuring current

To measure the current taken by the VDD supply the following hardware modifications should be made to the Performance Board - see Figure 48: Measuring current board modifications

- 1. Unsolder VDD solder bump, this isolates the DA7280 VDD Power supply from the USB supply.
- 2. Externally supply VDD at 3.7 Volts and GND to the Power Connections header.
- 3. If the GUI is connected to DA7280 ensure Polling Enabled/Disabled button is disabled.

To measure VDDIO supply, the following modifications should be made.

- 4. Unsolder the following solder bumps to isolate VDDIO supply VDDIO, SCLK, SDA, NIRQ, GPIO, GPI1, and GPI2.
- 5. Remove R5, powers down accelerometer.
- 6. Remove R32, powers down Cap Sense circuitry.
- 7. If the GUI is connected to DA7280 ensure Polling Enabled/Disabled button is disabled.





# **Revision History**

Revision	Date	Description
1.0	26-Mar-2018	Initial version
1.1	18-April-2018	Updated scripts section.
1.2	14-August-2018	Updated sections 8 and 9.
1.3	03-October-2018	Changed Jahwa script names to 1040. DA7280 GUI UI updated.



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