

Mini Digital Piano with Analog Discovery

Case Study

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1. Overview

Short description: This **Case study** explores how simple pushbuttons can be used to create a mini digital piano by controlling different sound frequencies. Participants press buttons connected to digital input pins and observe how each button selection changes the generated signal frequency, producing different musical notes through a piezo buzzer. Analog Discovery Product Line (AD 3 or AD Studio / Studio MAX, hereby **Device**) reads the button states through digital lines and generates the corresponding pulse signal using waveform generator.

Objectives

- Understand how pushbuttons can be used as digital inputs to control a mini digital piano.
- Configure digital lines on the **Device** to detect button states and assign each button to a specific musical note frequency.
- Generate pulse signals with different frequencies using waveform generator and observe how frequency changes produce different sound pitches through the piezo buzzer.

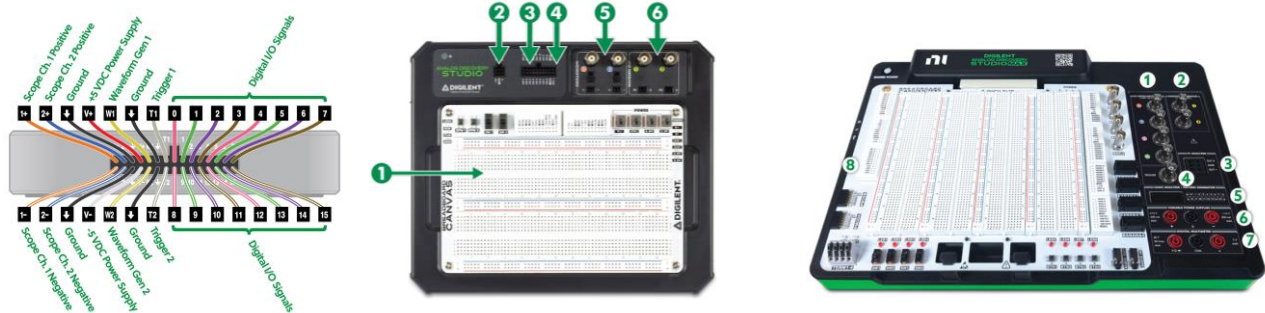
Software & Hardware Requirements

Software		Version
Digilent WaveForms (Runtime + SDK)		Latest (64-bit)
NI LabVIEW		2025 64-bit
WaveForms Toolkit for LabVIEW		Latest
Hardware		Quantity*
Digilent Analog Discovery Product Line		
Option 1	Digilent Analog Discovery 3	1
Option 2	Digilent Analog Discovery Studio	1
Option 3	Digilent Analog Discovery Studio MAX	1
List of Components		Quantity*
Canvas Breadboard		1
Push buttons		7
Resistor 10kΩ		7
Piezo buzzer		1
Jumper wires		-
BNC to BNC cable ¹		1

¹ BNC cable required only for the Analog Discovery Studio MAX.

2. Hardware Setup

This section describes the **Digilent Analog Discovery Product Line** hardware setup for **Case studies**. Before assembling the measurement circuit, it is essential to understand the pinout and available connections of the **Devices**. **Figure 1** highlights the pinouts and instrumentations of the Digilent Analog Discovery product line.²



a. Analog Discovery 3

- Power Supplies
- Logic Analyzer and Pattern Generator
- Triggers
- Oscilloscope Waveform Generator

b. Analog Discovery Studio

1. Breadboard Canvas
2. Power Supplies
3. Logic Analyzer and Pattern Generator
4. Triggers
5. Oscilloscope
6. Waveform Generator

c. Analog Discovery Studio MAX

1. Oscilloscope
2. Waveform Generator
3. IV Analyzer
4. Trigger
5. Logic Analyzer and Pattern Generator
6. Variable Power Supplies
7. Digital Multimeter
8. Breadboard Canvas

Figure 1. Digilent Analog Discovery Products Pinout and Instrumentations

Table 1 provides a common reference for physical channels' names across the **Digilent Analog Discovery product line**. The **Case studies** are designed to work with all supported devices, so the generic channels' names shown in the first row are used consistently in all circuit diagrams and wiring instructions.

Table 2 provides a common reference for device names and instrument identifiers used in NI LabVIEW with the WaveForms Toolkit across the **Digilent Analog Discovery product line**. The Case studies are designed to work with all supported devices; therefore, the generic instruments and

² For detailed electrical specifications, pin descriptions, and operating limits, always refer to the official datasheets of each device (Analog Discovery 3, Analog Discovery Studio, and Analog Discovery Studio MAX). The latest datasheets are available on the Digilent website:

- [Analog Discovery 3](#)
- [Analog Discovery Studio](#)
- [Analog Discovery Studio MAX](#)

channels identifiers shown in Table 2 are used consistently throughout the LabVIEW block diagrams and configuration steps.

Table 1 Physical Channels Mapping for Digilent Analog Discovery Devices

<i>Channel Device</i>	<i>WG 1</i>	<i>D0-D6</i>	<i>+Vs</i>
AD 3	W1 (Wavegen channel)	Digital Channels 0-6	+VDC Power Supply (Pin V+)
AD Studio ³	Wavegen Out 1		+5.0V (on canvas board)
AD Studio MAX	Function Generator 1		+5.0V (on canvas board)

Table 2 Device Names and Instruments Identifiers in NI LabVIEW (WaveForms Toolkit)

<i>Identifier Device</i>	<i>Device name</i>	<i>Digital Lines</i>	<i>Wavegen</i>
AD 3	Discovery3	dig/0:6	fgen/1
AD Studio	DiscoveryStudio		
AD Studio MAX	ADS_Max		

³ For the Analog Discovery Studio and Analog Discovery Studio MAX, ensure the devices are powered by turning ON the main power switch before use.

3. Background Information

A mini digital piano is a simple electronic system that uses pushbuttons as digital inputs to select and generate different musical notes. In this **Case study**, seven pushbuttons are connected to the digital input/output pins **DIO0–DIO6** of the **Device**. Each button represents one musical note from the C major scale. When a button is pressed, the **Device** detects the active digital input and generates a pulse signal with the corresponding frequency using **Wavegen 1**.

The generated pulse signal is applied to a piezo buzzer. The piezo converts the electrical signal into sound by vibrating at the selected frequency. Higher frequencies produce higher-pitched sounds, while lower frequencies produce lower-pitched sounds. For example, pressing the button connected to DIO5 generates a 440 Hz signal, corresponding to the musical note A4.

4. Circuit Design – step by step instructions

4.1 Description

The mini digital piano circuit is based on a set of pushbutton switches used as digital input keys. Seven pushbuttons, SW0–SW6, are connected to the digital input/output channels **DIO0–DIO6** of the **Device**. Each pushbutton represents one musical note. One side of each switch is connected to the positive supply voltage $+V_s$, while the other side is connected to the corresponding DIO pin. A 10 k Ω pull-down resistor is connected from each DIO input line to ground (GND). This ensures that when a button is not pressed, the corresponding DIO input remains at logic LOW. When a button is pressed, the DIO input is connected to $+V_s$, producing a logic HIGH signal.

The **Device** continuously reads the states of **DIO0–DIO6** and determines which button is pressed. Based on the active digital input, the software selects the corresponding musical note frequency. The selected frequency is then generated as a pulse signal using **Wavegen 1 (WG 1)**. The output of **WG 1** is connected to the positive terminal of the piezo buzzer, while the negative terminal of the buzzer is connected to GND. As the frequency of the generated pulse signal changes, the piezo buzzer produces different sound pitches, creating a simple mini digital piano.

For Analog Discovery 3, the positive supply output can be configured as **+5 V** and used as $+V_s$ for the pushbutton circuit. The negative supply output is not required for this setup and should remain disabled.

Important! Refer to **Table 1** to determine the exact physical pin, connector, or cable that corresponds to each generic connection on the specific Digilent Analog Discovery device being used. The remaining rows in the table show how each generic channel maps the actual hardware connections for each device.

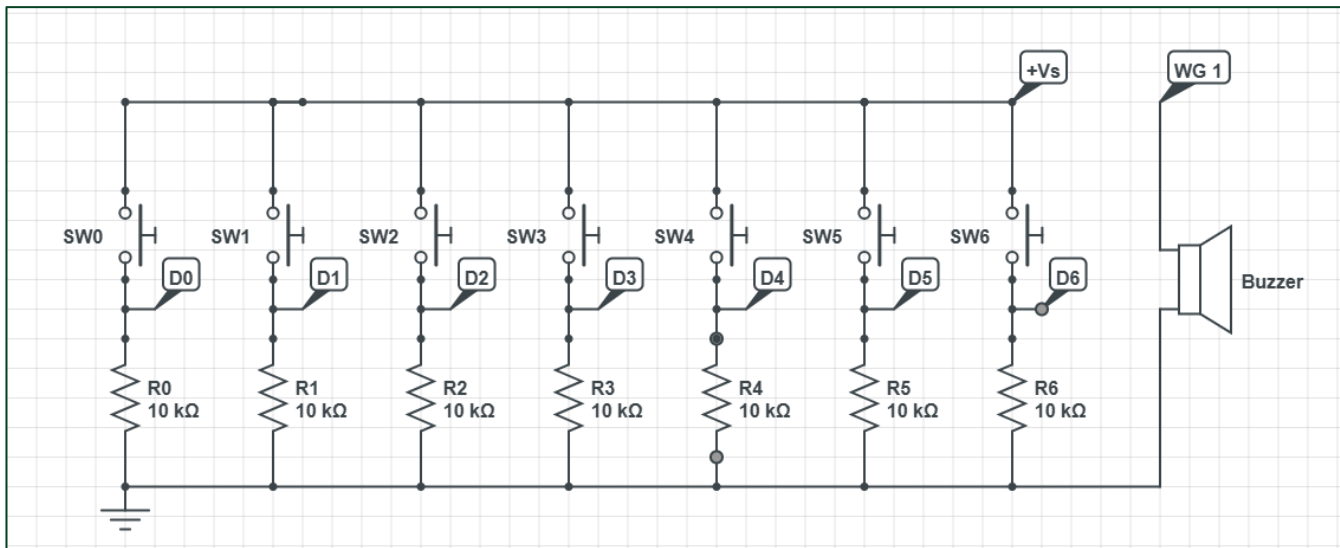


Figure 3. Mini Digital Piano Circuit

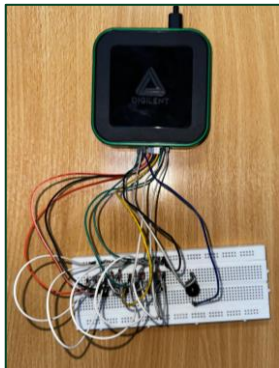
4.2 Step by step instructions⁴

1. Place seven pushbuttons **SW0–SW6** on the Canvas breadboard, ensuring that each button is inserted correctly and its terminals are not shorted together.
2. Place seven 10 kΩ resistors **R0–R6** on the breadboard. These resistors will be used as pull-down resistors for the digital input lines.
3. Connect one side of each pushbutton **SW0–SW6** to the **Device** positive supply **+V_s**.
4. Connect the other side of each pushbutton to the corresponding digital input pin of the **Device**.
5. Connect a 10 kΩ pull-down resistor from each digital input line to GND:
6. Connect the **Device** GND to the breadboard ground rail. This ground must be common for the pushbutton circuit, pull-down resistors, and buzzer circuit.
7. Place the piezo buzzer on the breadboard or circuit area.
8. Connect Wavegen 1 output **WG1** to the positive terminal of the piezo buzzer.
9. Connect the negative terminal of the piezo buzzer to GND.
10. Ensure that the **Device** positive supply **+V_s**, DIO inputs, pull-down resistors, **Wavegen 1** output, and buzzer all share the same common GND reference.

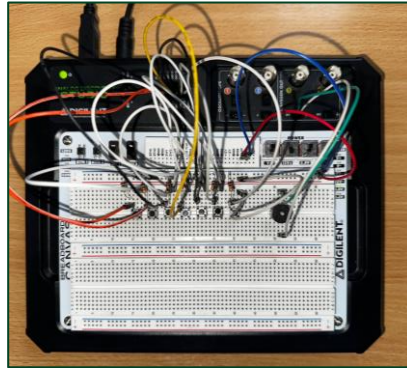
⁴ Given on Figure 3.

4.3 Assembled Circuit

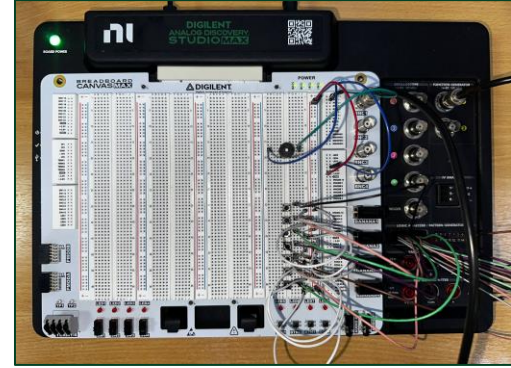
Figure 4 presents complete experimental circuits on different Digilent devices.



a. Analog Discovery 3



b. Analog Discovery Studio



c. Analog Discovery Studio MAX

Figure 4. Assembled circuits for different Devices

5. Software Setup - step by step instructions

5.1 Mini Digital Piano Control in WaveForms Using Script

Step 1. Launch WaveForms and connect the device

- 1.1. Connect the **Device** to the computer via USB.
- 1.2. Open the **Digilent WaveForms** software.
- 1.3. Verify that the device is detected and shown as *Currently Selected* in the **Device Manager** (Settings -> Device Manager).

Step 2. Configure the Power Supply in WaveForms⁵

- 2.1. Open the **Supplies** instrument in **WaveForms**.
- 2.2. Enable the **Positive Supply (V+)**.
- 2.3. Set the output voltage to **+5.000 V DC**.
- 2.4. Enable the **Master Enable** switch to activate the power output.
- 2.5. Keep the **Negative Supply (V-)** disabled (a single positive voltage is only required for the LDR voltage divider circuit).

Figure 5 shows the configuration of the **Device** power supply using the Digilent WaveForms environment.

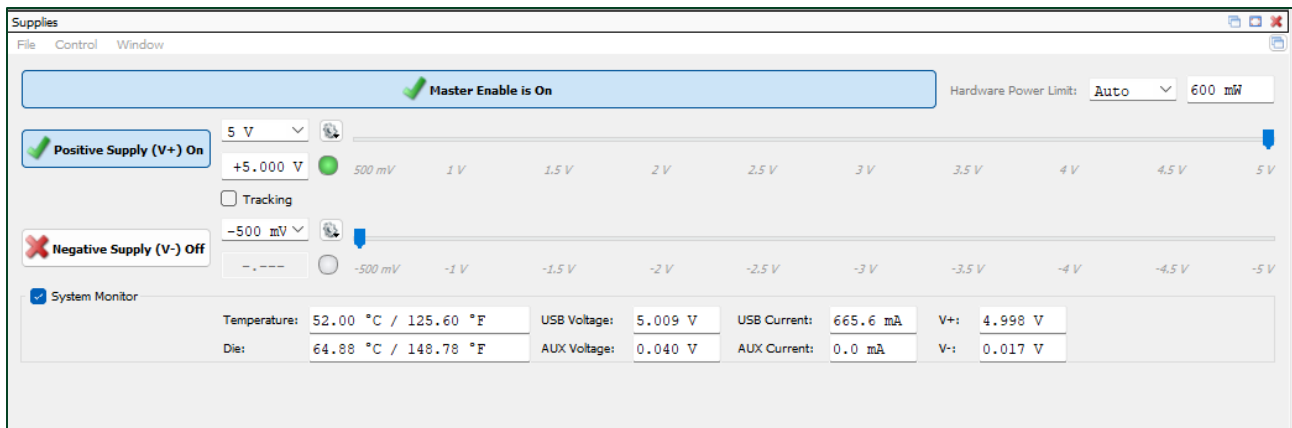


Figure 5. Power Supply Configuration in WaveForms Software

Step 3. Open the Script instrument - From the WaveForms main window, open the Script instrument.

The Script tool allows WaveForms instruments such as Supplies, StaticIO, and Wavegen to be controlled automatically using script-style commands.

Step 4. Insert and run the mini digital piano script - Copy the provided Mini Digital Piano script into the Script Editor window (Figure 6). The script automatically performs the following operations:

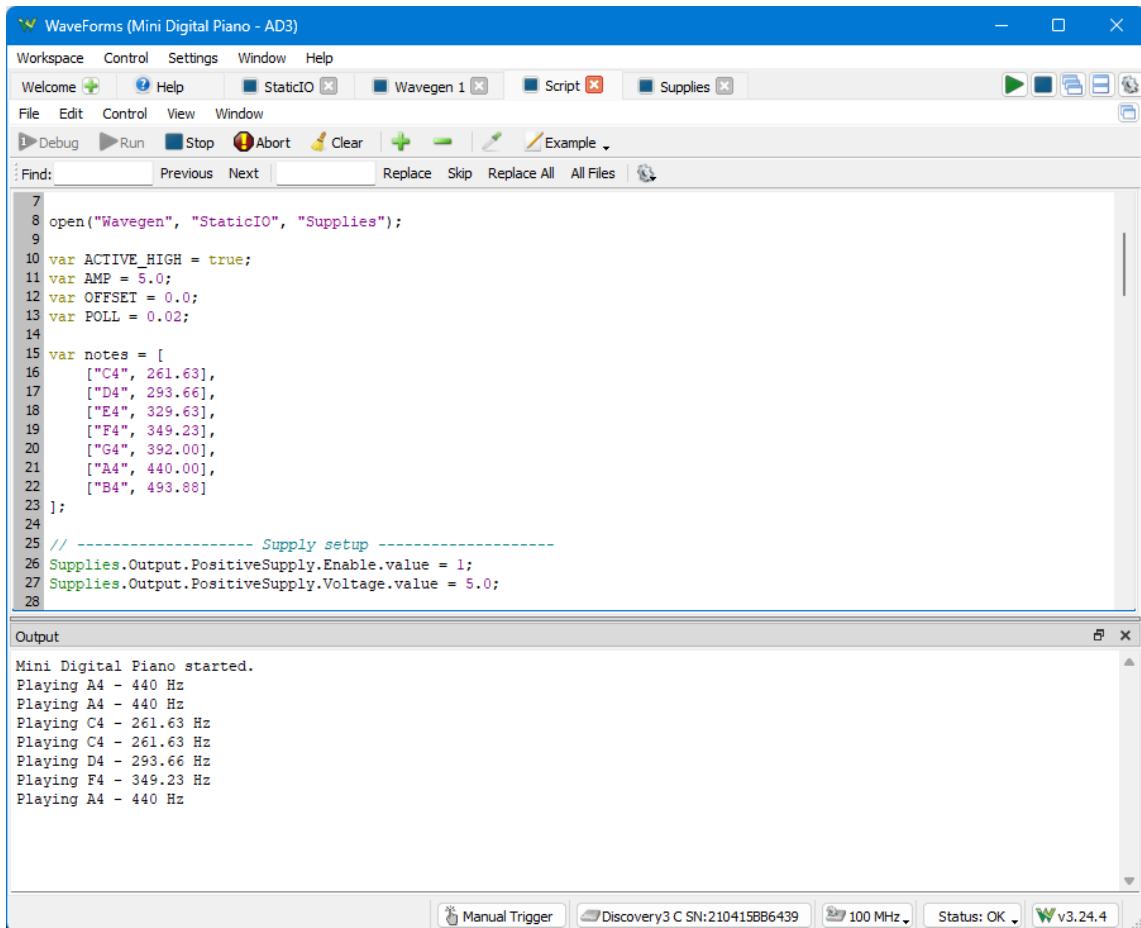
- Enables the positive supply and sets it to +5 V (only for AD3).
- Keeps the negative supply disabled.
- Configures DIO0–DIO6 as digital input pins.
- Reads the button states from DIO0–DIO6.

⁵ This step is mandatory for the Digilent Analog Discovery 3. Skip if you are using another device.

- Selects the corresponding musical note frequency.
- Generates a pulse signal using Wavegen 1.
- Sends the pulse signal to the piezo buzzer.

The button-to-note mapping is:

Button	DIO Pin	Note	Frequency
SW0	D0	C4	261.63 Hz
SW1	D1	D4	293.66 Hz
SW2	D2	E4	329.63 Hz
SW3	D3	F4	349.23 Hz
SW4	D4	G4	392.00 Hz
SW5	D5	A4	440.00 Hz
SW6	D6	B4	493.88 Hz



```

7
8 open("Wavegen", "StaticIO", "Supplies");
9
10 var ACTIVE_HIGH = true;
11 var AMP = 5.0;
12 var OFFSET = 0.0;
13 var POLL = 0.02;
14
15 var notes = [
16   ["C4", 261.63],
17   ["D4", 293.66],
18   ["E4", 329.63],
19   ["F4", 349.23],
20   ["G4", 392.00],
21   ["A4", 440.00],
22   ["B4", 493.88]
23 ];
24
25 // ----- Supply setup -----
26 Supplies.Output.PositiveSupply.Enable.value = 1;
27 Supplies.Output.PositiveSupply.Voltage.value = 5.0;
28

```

Output

```

Mini Digital Piano started.
Playing A4 - 440 Hz
Playing A4 - 440 Hz
Playing C4 - 261.63 Hz
Playing C4 - 261.63 Hz
Playing D4 - 293.66 Hz
Playing F4 - 349.23 Hz
Playing A4 - 440 Hz

```

Manual Trigger Discovery3 C SN:210415BB6439 100 MHz Status: OK v3.24.4

Figure 6. Mini Digital Piano Script in WaveForms Script Editor

Step 5. Run and test the mini digital piano

Click Run in the Script Editor. Press each button from SW0 to SW6 and confirm that the buzzer produces a different pitch for each key. If multiple buttons are pressed at the same time, the script plays the first detected active input.

Step 6. Optional: observe the generated signal using the Oscilloscope

To visualize the generated waveform, connect **Wavegen 1 (WG1)** to **Scope Channel 1 Positive**, and connect **Scope Channel 1 Negative** to **GND**. Open the **Scope** instrument, enable **Channel 1**, and adjust the time base and voltage range until the pulse waveform is clearly visible.

5.2 Mini Piano Using NI LabVIEW WaveForms Toolkit

Step 1. Launch NI LabVIEW and connect the Device

- 1.1. Connect the **Device** to the computer via USB.
- 1.2. Open **Digilent Waveforms** and verify that **Device** is detected and shown as *Currently Selected* in the **Device Manager** (Settings -> Device Manager), then close **Digilent Waveforms** software⁶.
- 1.3. Open the **NI LabVIEW** software.
- 1.4. Create a new NI LabVIEW VI (**File->New VI**)

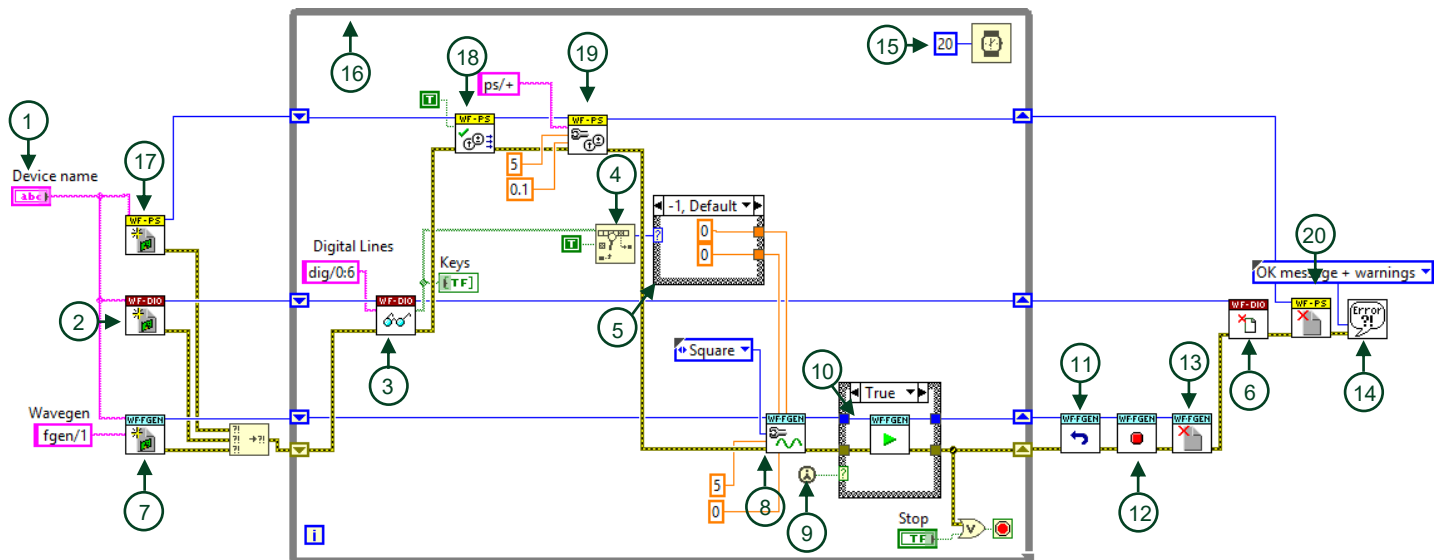
Step 2. Create Block Diagram and Front Panel in NI LabVIEW

- 2.1. Modify the block diagram as shown in **Figure 7.1** and **Figure 7.2**.

Figure 7.1 shows the LabVIEW block diagram code applicable only to ADS and ADS Max devices.

Figure 7.2 shows the LabVIEW block diagram code applicable only to the AD 3 device.

⁶ Before running NI LabVIEW, please ensure that the Digilent WaveForms software is closed.



1. **Device Name** - specify the name of your **Device**. Use **Table 2** for your **Device**.
2. **WF-DIO Initialize** - this VI initializes the digital lines.
3. **WF-DIO Read** - Transfer digital lines data from the **Device** to NI LabVIEW.
4. **Search 1D Array** - searches the Keys Boolean array and returns the index of the first pressed button.
5. **Case Structure for button index** - checks the detected button index. If no button is pressed, the output frequency and amplitude are set to 0. If a button is pressed, the corresponding note frequency is selected.
6. **WF-DIO Close** - closes the digital lines session and releases the DIO resources.
7. **WF-FGEN Initialize** - initializes the Wavegen / function generator session.
8. **WF-FGEN Configure Standard Waveform** - configures Wavegen 1 signal settings, including waveform type, amplitude, offset, and selected frequency.
9. **First Call?** - returns TRUE only during the first iteration of the While Loop. It is used to run the Wavegen output only once at the beginning, instead of starting it again in every loop iteration.

10. **Case Structure for Wavegen run** - receives the Boolean output from First Call?. In the TRUE case, it executes WF-FGEN Run to start Wavegen. In the FALSE case, no run command is needed because Wavegen is already running.
11. **WF-FGEN Reset** --resets the Wavegen settings before closing the function generator session.
12. **WF-FGEN Stop** - stops the Wavegen output signal.
13. **WF-FGEN Close** - closes the Wavegen / function generator session.
14. **Simple Error Handler** - displays possible errors or warnings during VI execution.
15. **Wait (ms)** - adds a short delay inside the While Loop. In this VI, the value is set to 20 ms.
16. **While Loop** - continuously reads the DIO buttons and updates the Wavegen output while the VI is running.
17. **WF-PS Initialize** - initializes the power supply session for the Device.
18. **WF-PS Enable** - enables the selected power supply output. For AD 3, this is used to provide +5 V for the pushbuttons.
19. **WF-PS Voltage** - configures the positive supply output voltage and current limit for the button circuit.
20. **WF-PS Close** - closes the power supply session.

- 2.2. Modify the front panel shown in **Figure 8**. Inside **Device name** String Control write your corresponding **Device** name from **Table 2**.

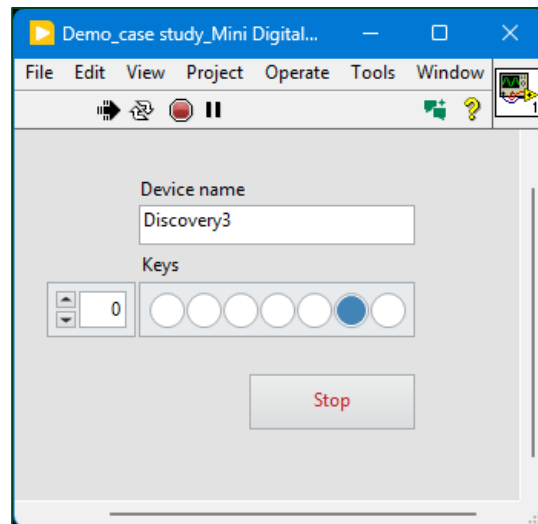


Figure 8. VI Front Panel

- 2.3. Save the VI.

Step 3. Run the code and test the mini digital piano in LabVIEW

- 3.1. Run the code by clicking on the **Run button**.
- 3.2. Press the pushbuttons SW0–SW6 one by one.
- 3.3. Observe that each button generates a different sound pitch from the piezo buzzer.
- 3.4. Try to play a song using mini piano.
- 3.5. Stop the VI using the Stop button.