

Topic 11:
Design, implementation and programming of the
Buzzer/Speaker Interface
for the Slow Control System MPD-NICA,
on the NImyRIO and LabView platforms.¹

Marek Jerzy PERYT

*Faculty of Physics, Warsaw University of Technology
Koszykowa 75, 00-662 Warszawa, Poland
Joint Institute for Nuclear Research
Dubna, J. Curie 6*

(Accepted June, 2018)

11 Buzzer/Speaker

The Buzzer/Speaker pictured in Figure 11.1 (also called a magnetic transducer) generates tones over much of the audible frequency spectrum. The speaker coil is designed for on-off operation (5 volts at 80 mA when on), therefore cycling the speaker with a square wave created from a digital output is the most straightforward way to operate the speaker. A transistor-based interface circuit is required to drive the coil.

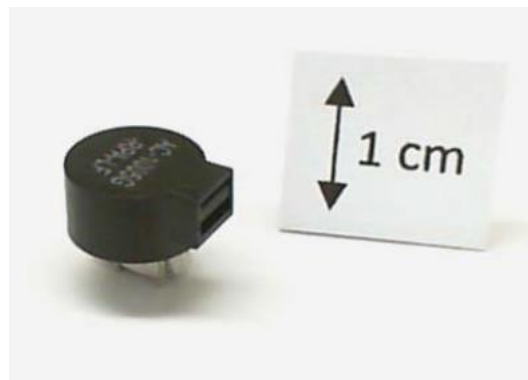


Figure 11-1; NImyRIO StarterKit Buzzer/Speaker.

11.1 Learning Objectives:

After completing the activities in this chapter you will be able to:

- [a] Describe the Buzzer/Speaker principle of operation based on an electromagnetic coil that vibrates a small diaphragm,
- [b] Select a transistor to drive the coil from a digital output,
- [c] Protect the transistor from back-EMF voltage spikes when the transistor switches the coil current on and off, and

¹ Developed on the basis of educational materials: National Instruments, IBM, Reichle & De-Massari, Microsoft, Warsaw University of Technology, Joint Nuclear Institute Research

- [d] Design the interface circuit to work with digital outputs that include either pull-up or pull-down resistors.

11.2 Component Demonstration

Follow these steps to demonstrate correct operation of the Buzzer/Speaker.

11.2.1 Select these parts from the NImyRIO StarterKit:

- [a] Buzzer/Speaker, Soberton GT-0950RP3,

<http://www.soberton.com/product/gt-0950rp3>

- [b] 1N3064 small-signal diode,

<http://www.fairchildsemi.com/ds/1N/1N3064.pdf>

- [c] 2N3904 npn transistor,

<http://www.fairchildsemi.com/ds/MM/MMBT3904.pdf>

- [d] Resistor, 1.0 k Ω

- [e] Breadboard

- [f] Jumper wires, M-F (3x)

11.2.2 Build the interface circuit:

Refer to the schematic diagram and recommended breadboard layout shown in Figure 11.2. Note that the two Buzzer/Speaker terminals do not sit on tenth-inch centers, however, they fit just fine in two diagonally-adjacent breadboard holes. The interface circuit requires three connections to NImyRIO MXP Connector B (see Figure A.1 Appendix):

- [a] 5-volt power supply \rightarrow B/+5V (pin 1)
- [b] Ground \rightarrow B/GND (pin 6)
- [c] Buzzer/Speaker control \rightarrow B/PWM0 (pin 27)

11.2.3 Run the demonstration VI:

- [a] Download

<http://www.ni.com/academic/myrio/project-guide-vis.zip>

- [b] if you have not done so previously and unpack the contents to a convenient location,
- [c] Open the project Buzzer-Speaker demo.lvproj contained in the subfolder Buzzer-Speaker demo,
- [d] Expand the hierarchy button (a plus sign) for the myRIO item and then open Main.vi by double-clicking,
- [e] Confirm that NImyRIO is connected to your computer, and
- [f] Run the VI either by clicking the Run button on the toolbar or by pressing Ctrl+R.

Expect to see a “Deployment Process” window showing how the project compiles and deploys (downloads) to NImyRIO before the VI starts running.

NOTE: You may wish to select the “Close on successful completion” option to make the VI start automatically.

11.2.4 Expected results:

Your Buzzer/Speaker should be making a low-frequency tone at 40 Hz. Move the front-panel control frequency [Hz] to increase the frequency. At what frequency is the sound output level the highest? What is the highest frequency that you can hear? Try blocking the port (rectangular hole) – how does this affect the sound at different frequencies?

Click the Stop button or press the escape key to stop the VI and to reset NlmyRIO; a myRIO reset causes all of the digital I/O pins to revert to input mode.

11.2.5 Troubleshooting tips:

Not hearing the expected results? Confirm the following points:

- [a] Glowing power indicator LED on NlmyRIO,
- [b] Black Run button on the toolbar signifying that the VI is in runmode,
- [c] Correct transistor orientation—the transistor has a rounded shape on one side, and Correct diode orientation — when the diode is backwards the Buzzer/Speaker coil will never reach the voltage level necessary to turn on.

11.3 Interface Theory

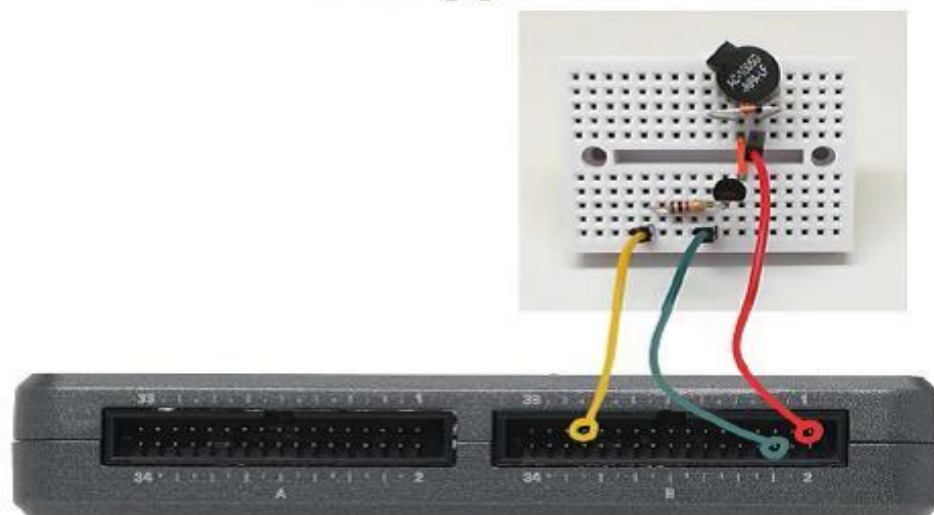
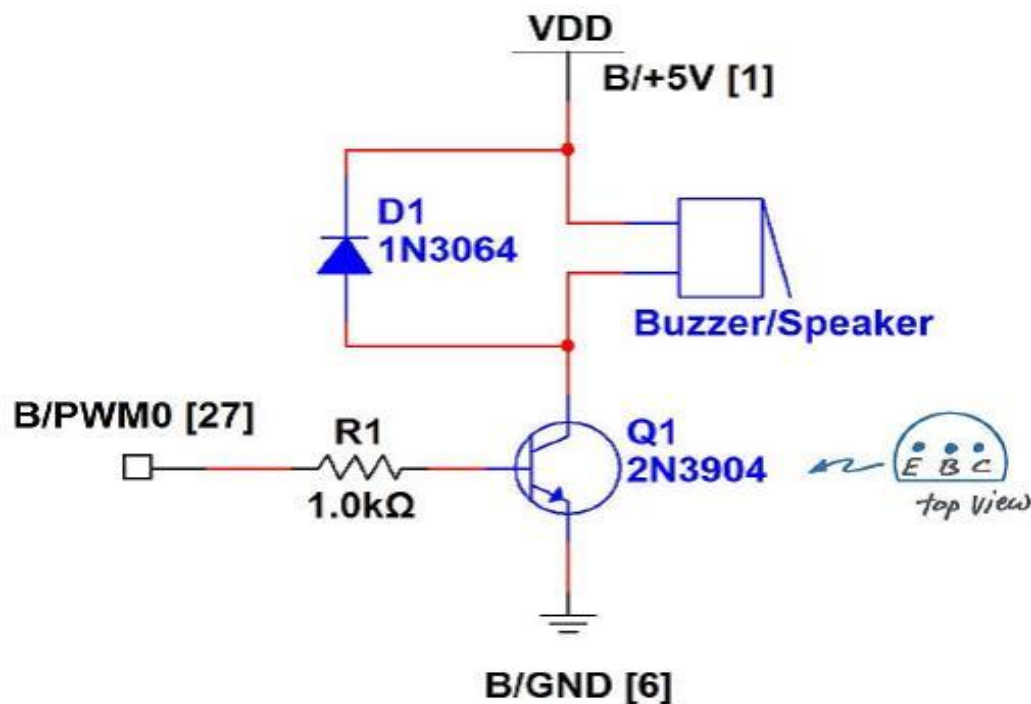


Figure 11-2; Demonstration circuit for Buzzer/Speaker: schematic diagram, recommended breadboard layout, and connection to NlmyRIO MXP Connector B.

11.3.1 Interface circuit:

The Buzzer/Speaker contains an electromagnetic coil that vibrates a small diaphragm. The coil current is approximately 80 mA, well beyond the current drive limits of the NImyRIO digital output. The interface circuit uses an NPN transistor as a switch to turn the coil current on and off and a diode to protect the transistor from large back-EMF voltage when the transistor abruptly shuts off the coil current.

Study the video *Buzzer/Speaker Characteristics* (5:14)

<https://www.youtube.com/watch?v=8lbTWH9MpV0&feature=youtu.be>

to learn more about the Buzzer/Speaker characteristics and interface circuit design principles including: sizing the transistor for relay coil current, importance of the diode to deal with back-EMF voltage spiking, and circuit topologies for DIOs with internal pull-up resistors (MXP connector) and internal pull-down resistors (MSP connector).

11.3.2 LabVIEW programming:

Study the video *PWM Express VI* (2:41)

<https://www.youtube.com/watch?v=mVN9jfwXleI&feature=youtu.be>

To learn how to use the PWM Express VI (PWM = Pulse-Width Modulation) to create a square wave output on B/PWM0 (pin 27) in the frequency range 40 Hz to 40 kHz with adjustable pulse width.

11.4 Basic Modifications

Study the video *Buzzer/speaker Demo Walk - Through* (2:06)

<https://www.youtube.com/watch?v=kW4v16GuAFE&feature=youtu.be>

to learn the design principles of Buzzer-Speaker demo, and then try making these modifications to the block diagram of *Main.vi*:

- [a] Add a front-panel control to adjust the waveform pulse width (called duty cycle) between 0 % and 100 %. How does a narrow pulse (low duty cycle) affect the tone quality at various frequencies?
- [b] Create a two-tone alarm signal with a Boolean front-panel control as an enable. Review Discrete LED demo.lvproj from Section 2.3 on page 7 to learn how to make a two-state oscillator.

11.5 Integrated Project Ideas

Now that you know how to use the buzzer/speaker consider integrating it with other devices to create a complete system, for example:

- [a] Music Maker (Topic 55)
- [b] NTP Clock (Topic 42)

11.6 For More Information

- [a] Products by Soberton Inc. ~ Discover related products to the Buzzer/Speaker in the NImyRIO StarterKit:

<http://www.soberton.com/products>

Bibliography:

- [b] www.jinr.ru
- [c] www.ni.com
- [d] www.nica.if.pw.edu.pl
- [e] The Multi-Purpose Detector – MPD to Study Heavy Ion Collisions at NICA; (CDR Conceptual Design Report) Version 1.4; Project leaders: A. N. Sissakian, A. S. Sorin, V. D. Kekelidze.
- [f] <http://www.soberton.com/product/gt-0950rp3>
- [g] <http://www.fairchildsemi.com/ds/1N/1N3064.pdf>
- [h] <http://www.fairchildsemi.com/ds/MM/MMBT3904.pdf>
- [i] <http://www.ni.com/academic/myrio/project-guide-vis.zip>
- [j] <https://www.youtube.com/watch?v=mVN9jfwXleI&feature=youtu.be>
- [k] <https://www.youtube.com/watch?v=8IbTWH9MpV0&feature=youtu.be>
- [l] <https://www.youtube.com/watch?v=kW4v16GuAFE&feature=youtu.be>
- [m] <http://www.soberton.com/products>