PMP15034 Test Results

System Description

A piezoelectric sounder is a loudspeaker that uses the piezoelectric effect to generate sound. It is widely used in the application where sound volume and high pitch are more important than sound quality, such as toys, air conditioner, microwave oven and alarm equipment.

The piezoelectric sounder normally required a 1-KHz to 5-KHz rectangular voltage to operate. The sound press mainly depends on the amplitude of the driving voltage. The higher driving voltage, the higher sound press will be. For example, the PKM13EPYH4002 from Murata requires 0-V to 30-V or +15-V to −15-V rectangular voltage. The power supply in these applications could be two cell alkaline battery, lithium-ion battery or 3.3-V, 5-V power rail, which is much lower than the target voltage. Therefore, a high performance, simple boost converter TLV61046A is required for this application.

TLV61046A is 1.8-V - 5.5-V input, up to 28-V output, full integrated boost converter. It integrates low side MOSFET, high side rectifier diode and the isolation MOSFET. The isolation MOSFET disconnects the pass-through path between input and output when the device is disabled. This function helps to reduce the battery power loss when the piezoelectric sounder doesn't work.

Based on TLV61046A, the reference design introduces two driving circuit of piezoelectric sounder. With PWM signal from MCU, one circuit provides rectangular wave driving voltage between 0-V and 28-V; the other circuit provides ±15-V rectangular wave driving voltage.

The block diagram of the 28-V driver circuit is shown in Figure 1. The output voltage of the TLV61046A is set to 28V. A PWM signal from MCU drives Q1 to control the voltage across the piezoelectric sounder LS. When PWM signal is logic high, the Q1 turns on, so 28V is applied to LS. When PWM signal is logic low and Q1 turns off, the LS is discharged by the resistor in parallel. The frequency of the PWM signal should be equal to the recommended frequency of the sounder. The duty of the PWM should be as low as possible to reduce the power loss when the sound press is acceptable.

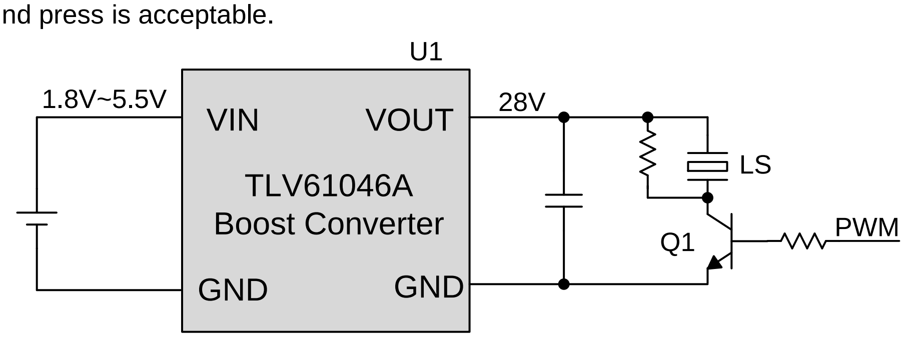

Figure 1: Block Diagram of the 28-V Driver Circuit

The block diagram of ±15-V driving circuit is shown in Figure 2. The output of the TLV61046A is set to 15V. An additional charge pump circuit doubles the output voltage to approximately 30V. When Q1 turn off and Q2 turn on, the voltage according the sounder LS is 15V; when Q1 turns on and Q1 turns off, the voltage according LS is -15V. The frequency of driving voltage follows the PWM input from MCU. By modifying the feedback divider of the TLV61046A and selecting proper Q1, Q2, this circuit supports ±28 V for the sound. The resistor in parallel with LS can discharge the voltage to zero after the boost converter is disabled.

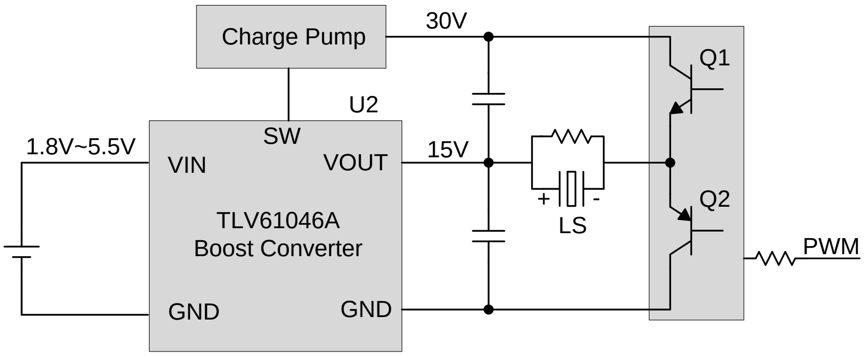

Figure 2: Block Diagram of ±15-V Driver Circuit

Design Theory

The schematic of the 28-V driver circuit is shown in Figure 3. The output voltage of the boost converter is configured by R1 and R3. This voltage should be set to as high as possible to get highest sound.

Q1 is a NPN device driven by the PWM signal from the MCU. The sounder TS1 is charged to 28V when Q1 turns on, and discharged by the R2 to 0V when Q1 turns off. The frequency of the PWM should be equal to the recommended operating frequency of the sounder, which is 4KHz in this reference design.

The duty cycle of the PWM and the R2 resistance impact the sound press of TS1. They also impact the power loss of the driver circuit because the current flows through R2 to ground when Q1 turns on.

The power loss of R2 is calculated by equation (1), where D is duty cycle of the input PWM signal.

$$P_{R2} = V_{OUT}^{2} \times D \div R2 \quad (1)$$

Follows are two steps to find suitable R2 and duty cycle to compromise the sound press and power loss:

- Setting the duty cycle to 50%, select a 1-KΩ to 10-KΩ resistor that minimize the power loss without suffering the sound press
- Using R2 selected by step 1, slowly decrease the duty cycle to minimize the power loss if the sound press requirement is met.

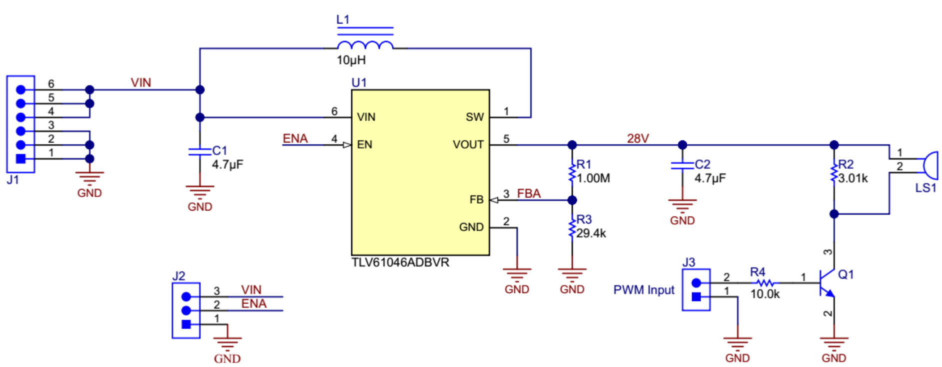

Figure 3: 28-V Rectangular Waveform Driver Circuit

The schematic of the ±15-V driver circuit is shown in Figure 4. the output voltage of the TLV61046A is set to 15V. The additional charge pump circuit doubles the output voltage to approximately 30V. The NPN Q2 and PNP Q3 form a totem pole driver circuit. The Q4 and R5 form a simple level shift circuit. When PWM is high voltage, the Q4 turns on. So the totem pole circuit outputs 0.7V. The voltage according LS2 is -14.3V. When the PWM is low voltage, the output voltage of totem pole circuit is 29.3V. So the LS2 voltage is 14.3V.

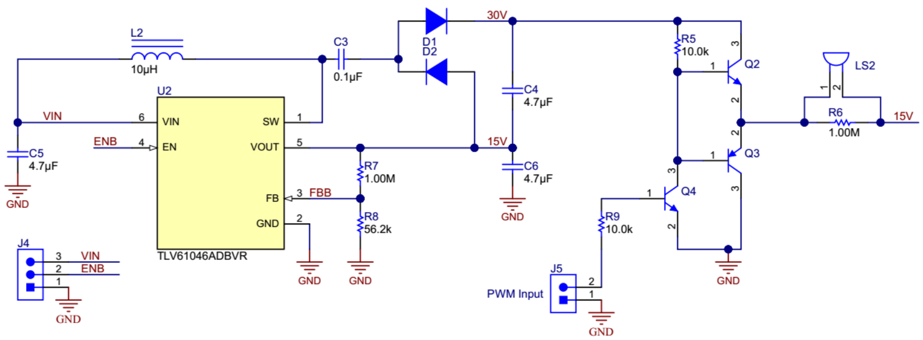

Figure 4: ±15-V Rectangular Waveform Driver Circuit

The current flowing through R5 to ground increases the power loss of the circuit. It is suggested to minimize the duty cycle of the PWM signal if the sound press meets the requirement.

The R6 in parallel with LS2 discharge the DC voltage at LS2 to zero after the TLV61046A is disabled.

Test Result

Figure 5 shows the startup waveform the 28-V circuit by EN signal. The device finishes startup process in 7ms. It is suggested that the PWM input signal is 7ms later than EN high logic.

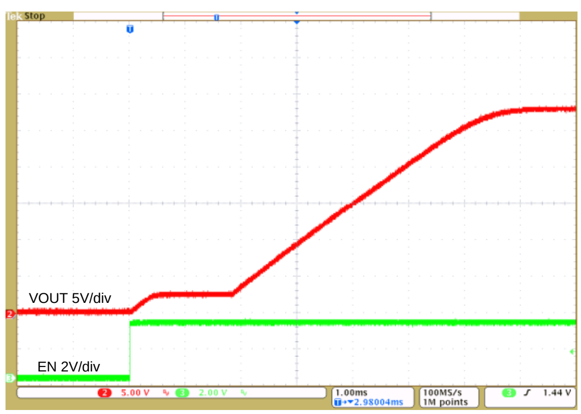

Figure 5: Startup at VIN=3.3V

Figure 6 shows operating waveform when the PWM input signal is 4KH with 30% duty and VIN = 3.3V. The sounder voltage is charged to 28V when the Q1 turns on, and discharged to almost 0 V by the resistor when the Q1 turns off

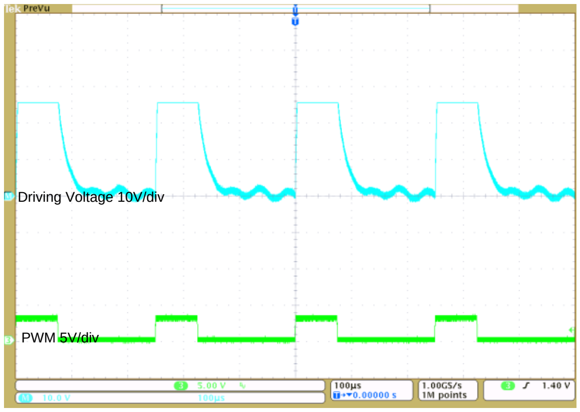

Figure 6: Operating Waveform with 4-KHz PWM

The startup by EN waveform of the ±15-V circuit is shown in Figure 7, the two output voltage ramps up to target value within 7ms.

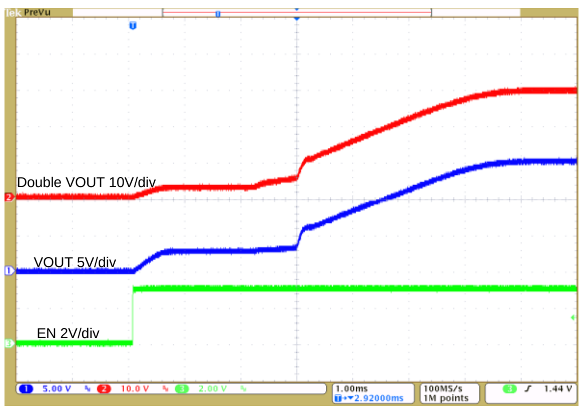

Figure 7: Startup at VIN=3.3V

Figure 8 shows the operating waveform with 4-KHz, 30% duty PWM input when VIN=3.3V. The rising and falling time is very short because the totem pole has strong driving capability.

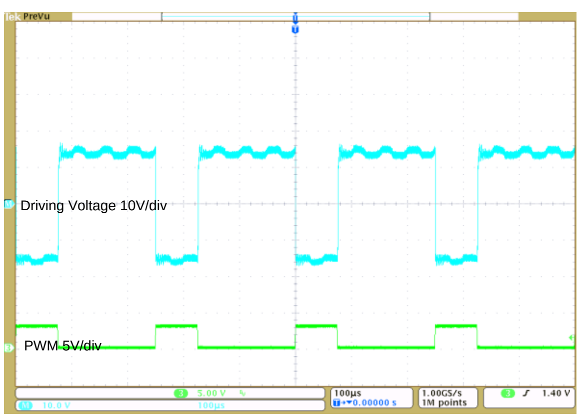

Figure 8: Operating Waveform with 4-KHz PWM

Mailing Address: Texas Instruments, Post Office Box 655303, Dallas, Texas 75265